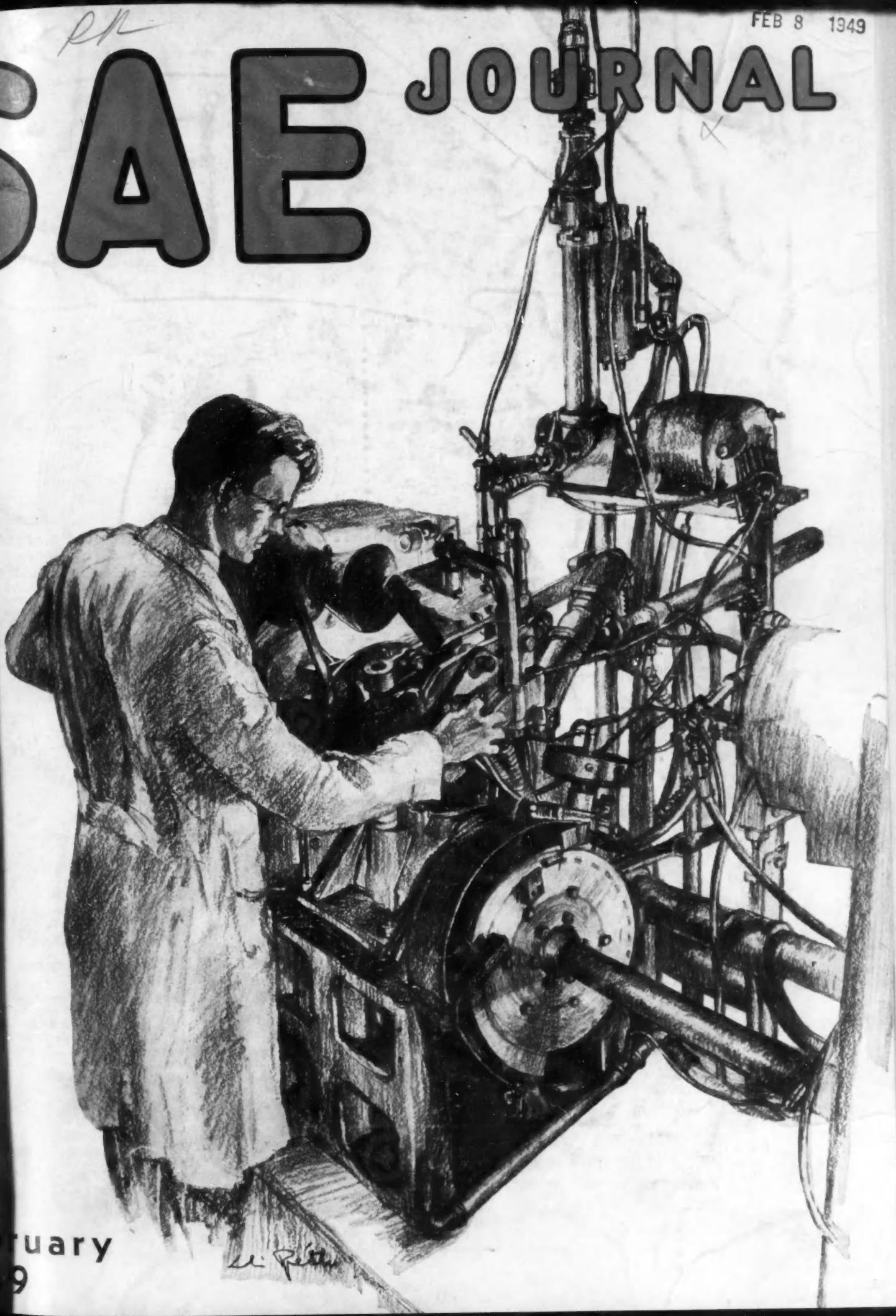
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SAE JOURNAL



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THE PERFECT CIRCLE Rumor Page



IT'S RUMORED THAT: ***The downdraft carburetor and automatic spark advance were used as early as 1902!***

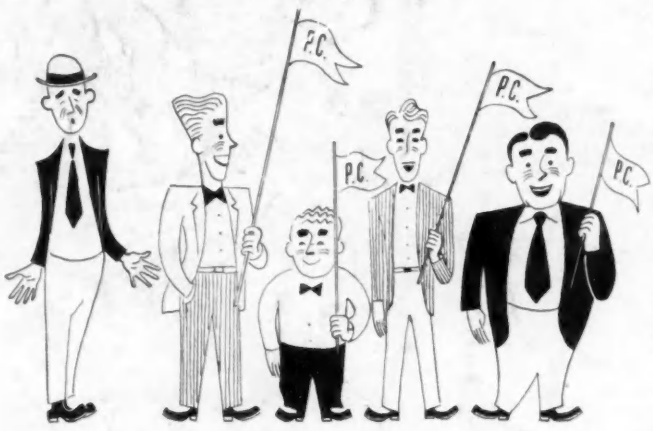
That's a fact. The 1902 chain-drive, rear-engine Rambler had these innovations incorporated in its first model. The Rambler was succeeded by the Jeffrey, and the name was later changed to Nash! There the name changes stopped. It's been Nash since 1917.

*Contributed by Ralph R. Weeker, Upper Darby, Pa.**



IT'S RUMORED THAT: ***Salt treated tire treads have been developed for icy roads!***

That's right. The manufacturer claims that up to 30% better traction is developed by a new rock-salt treated tread. The process is intended for recapping purposes rather than for new tires. It is hoped that the result will be safer driving under winter conditions, although it is not designed to replace skid chains.



IT'S RUMORED THAT: ***You, gentlemen, say it's us — four-to-one!***

Yes, and thank you, very much! A recent survey of automotive engineers, readers of the S.A.E. Journal, showed Perfect Circle leading by better than four-to-one in first place answers to the question: "What is the best engineered piston ring?" The survey was conducted by an independent survey company. We are happy that you think we know our job.



IT'S RUMORED THAT: ***In Akron, they are testing a "rubber street"!***

Yes, it's true. Shreds of synthetic rubber are mixed with asphalt blacktop and the resultant "hot-mix" applied to the street. Experimenters claim that the new surface is more waterproof and resilient, hence less likely to crack under freezing conditions, and that it also wears better. For purposes of the test, one-half the street is paved with the new mix and the other with regular asphalt. Mighty snappy!



*Perfect Circle pays $50.00 for any Rumor accepted for this page. None can be returned or acknowledged, and all become PC's property. Send yours to Perfect Circle Corporation, Hagerstown 9, Indiana.

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■ SAE JOURNAL PUBLICATION OFFICE
BUSINESS PRESS, Inc.
10 McGovern Ave.
Lancaster, Pa.

EDITORIAL OFFICE
29 West 39th St.
New York 18, N. Y.
Tel.: Longacre 5-7174

ADVERTISING OFFICES
E. L. Carroll
Eastern Adv. Mgr.
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FEBRUARY

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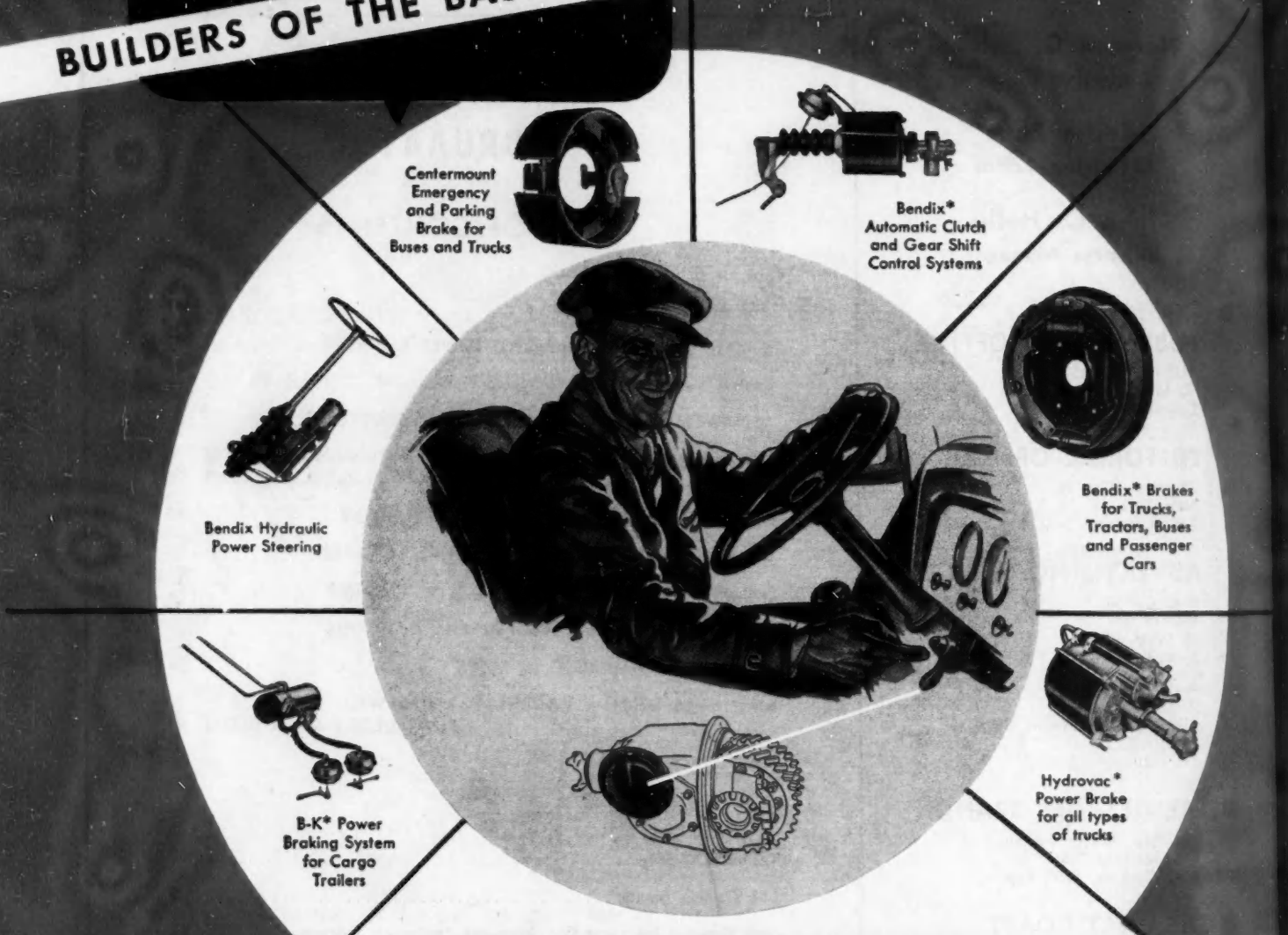
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CHALLENGES

In All SAE Fields Posed At 1949 Annual Meeting

TORQUE converters and fuel economy topics drew capacity crowds at the 1949 SAE Annual Meeting, Jan. 10-14, in Detroit, where near-record registration totals were hung up.

Throughout the week technical challenges to the engineer were detailed in almost every phase of SAE activity, and at the Annual Meeting Dinner Economic Cooperation Administrator Paul G. Hoffman, as well as 1948 SAE President R. J. S. Pigott and 1949 SAE President Stanwood W. Sparrow posed additional challenges to their listeners as citizens of the United States as well as engineers.

Robert F. Black, president of White Motor Co., was toastmaster at the dinner; Detroit Section Chairman E. P. Lamb, Chrysler Corp., introduced Black and welcomed the members to Detroit in the name of the Society's largest Section.

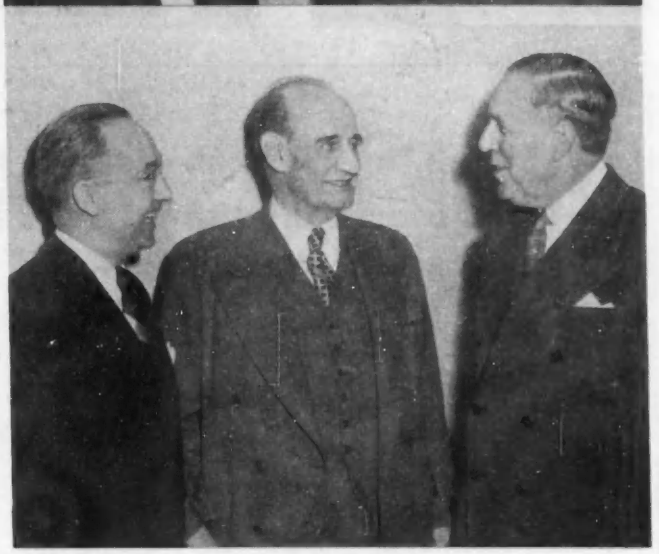
Hoffman Warns of Russia

"As long as communism—with its false cry of brotherhood, its blurred vision of a classless society—stands on our frontiers," Hoffman warned, "there can be no respite from its challenge. It isn't merely a question of hoping—nor of praying—for ECA's success," he said. "We must translate hope into reality—and thus build a foundation for enduring peace. Only by so doing can we make sure that the free people of the world can remain free."

Hoffman voiced his conviction that the primary objective of Russia is to establish a world dictatorship by promoting satellite police states . . . and admitted that Russia has every right to be well pleased with the progress of its campaign since V-J Day. The existence and the progress of the Marshall Plan, he said, prevented Italy and France from becoming Russian police states—and its continued success, he felt, will be a major element in bringing a stable Western Europe and an enduring peace.

"Ours must be a three-front operation," he stressed—"and that means military preparedness as well as political and economic stability." Among tangible evidences of recovery in Western Europe, he cited upped coal production of 420 million tons in Marshall Plan countries for the fiscal year ending 1949 as compared to 1947, an increase of 8% in kilo-





TOP: Stanwood W. Sparrow, 1949 SAE President (left), with 1948 President R. J. S. Pigott. BOTTOM (left to right): Ernest P. Lamb, chairman of the SAE Detroit Section; Toastmaster Robert F. Black, president of White Motor Co., and Paul G. Hoffman, administrator of the Economic Cooperation Administration, principal speaker at the Annual Meeting Banquet in Masonic Temple



L. Ray Buckendale, right, 1946 SAE President, receiving his certificate of Life Membership from 1948 President R. J. S. Pigott

watt hours of electricity produced, and 50% in crude steel. . . . "The tide of communism is ebbing in Western Europe wherever the Marshall Plan has gone," he stated. And the program looks to success in terms much more far reaching than mere production figures. . . . "It proposes, in fact," Hoffman concluded, "an economic cooperation between the participating countries that would break down barriers that have divided Europe in uneconomic segments for centuries and which, even before World War II, were threatening its economic life." . . . ECA has asked the cooperating countries to tabulate all the barriers that slow down and stop the movement of goods between the nations of Western Europe—and is insisting upon a steady reduction and elimination of these barriers.

Pigott Optimistic on Fuel

1948 SAE President R. J. S. Pigott, chief engineer, Gulf Research & Development Co., spoke optimistically of the existing petroleum supply in the light of technological progress already made or in the making. He expressed deep appreciation for the "education" he said he received while executing his duties as president and visiting all but one of the Society's 38 Sections and Groups.

Sparrow Looks Ahead

In a brief inaugural address, 1949 President Stanwood W. Sparrow, vice-president of engineering, The Studebaker Corp., shunned the role of prophet, but voiced confidence that the Society is well equipped to meet whatever conditions may arise. He said in part:

"Conditions determine problems as well as the best techniques for their solution. . . . We hope for a year of peace, but war is not impossible. We hope for a year of prosperity, but times might get tough. . . . Your Society has the best of tools in its staff, its committees, and—most important of all—in the ability and spirit of its members. I am confident that, whatsoever may be the problems that confront us, they will be tackled with enthusiasm and solved with credit . . . and that in working out the solution we will find satisfaction and pleasure."

Life Membership to Buckendale

At the business session of the Society on Tuesday evening, Jan. 11, Past-President L. Ray Buckendale was presented with Life Membership in the Society.

DESIGNERS ASKED

To Help on Problems Outside Direct Area

Based on discussions and five papers presented at one Body session, one Production session, one Truck and Bus session, one Aircraft session, and one Engineering Materials session. . . . "Body Design and Production Today," by **L. C. Goad**, General Motors Corp. . . . "Preparedness Plans and Programs," by **Lt.-Gen. LeRoy Lutes**, director of the Staff, Munitions Board, National Military Establishment. . . . "Petroleum Scarcity and Cost Increases," by **R. J. S. Pigott**, Gulf Research and Development Co. . . . "Cost Cutting Chance Laws Can Control Design Tolerances," by **Dorian Shainin**, Hamilton Standard Propeller Division, United Aircraft Corp. . . . "Steel Composition and Specifications—From the Producer's Viewpoint," by **C. M. Parker**, American Iron and Steel Institute. . . . **All of these papers will appear in abridged or digest form in forthcoming issues of the SAE Journal, and those approved by Readers Committees will be published in full in SAE Quarterly Transactions.**

AUTOMOTIVE designers were charged with measurable responsibilities for conserving basic fuel supplies, helping to reduce production costs, better utilizing remaining supplies of the raw materials of steel production, and generally increasing the efficiency of every other department in their factories by improved understanding and cooperation. At a variety of sessions throughout the meeting, representatives of other industries and departments took occasion to ask designers' help on other than strictly design problems—and, in a number of instances—to detail ways in which that help might be given.

To conserve dwindling fuel resources, for instance, it was suggested that engine designers transfer all energy use possible to solid fuel, from liquid, reserving liquid and gaseous fuels for those operations which cannot do without them. Need for such

transfer was pointed up by an estimate of:

Total Reserve at 1947 Consumption

	Max No. Yr	Min No. Yr
Coal	1700	170
Petroleum	16	5
Natural Gas	12	5
Oil Shale	32	5

(These estimates were on the basis of *each* of the fuels being used for the whole energy supply, so the whole could be added to arrive at a total energy supply.)

They were urged, also, to raise the efficiency of all heat and power transformations, while researchers continue trying to determine the best methods for supplementary supply of liquid fuels, at the nearest to reasonable economic production and permanence. Current development of practical, higher compression engines was cited as one specific move for improvement of engine efficiency which would be beneficial to conservation of fuel supply in the long run.

Desirability of lighter automobiles as a means to fuel conservation also was expressed, but it was generally agreed that petroleum price and supply—"economics"—would determine when, if, and how much the public is willing to sacrifice comfort and performance to fuel economy.

Superchargers as a substitute for high compression engines were spoken of with considerable favor by some; with considerable skepticism by others.

The possibility of near-future gas turbines suitable for motor vehicle use—mentioned casually by one discusser—was discounted by most engineers both in and out of formal discussions.

The basic challenge to automotive designers was dramatized by one speaker with the statement that: "Overall average load utilization efficiencies in the field of domestic heating and industrial fields average 59% and 42% respectively. In contrast, the transportation field average is about 6%."

The designers were praised for leading the way in development of usage of certain types, grades, and qualities of steel of limited tonnage application. . . . But, in respect to a very much larger tonnage of steel, they were said to have been content to present a design and challenge to the steel producer to make steels which would behave properly and economically in fabrication and service.

Steel spokesmen, feeling that those challenges have been met successfully, think the designers should be willing to concentrate more on demanding performance requirements and less on detailed specifications.

Said one: it is difficult to reconcile technically the present great interest specificationwise in restrictive requirements which embrace chemical compositions, mechanical properties, fabricating requirements, and end use requirements in the face of the relationship between the steel and the automotive industries." . . . Many times the steelmaker is put to a great deal of trouble and unnecessary cost to meet a requirement which is technically and economically unsound even for the consumer.

One reason for steel industry pressures on this point, it was brought out, is the increasing difficulties involved in meeting too detailed specifications because reserves of high-grade raw materials have been deleted to such an extent that the known remaining materials are either inferior in quality or remote from established centers of steel production.

This inferior quality imposes difficult technological problems, steel spokesmen contended, some of the consequences of which may have to be passed on to consumers of steel temporarily or permanently, depending upon their successful solution and eco-



Lt.-Gen. LeRoy Lutes
Director of the Staff, Munitions Board
National Military Establishment

HOW the U. S. military services are preparing to mobilize industrial facilities against any possible emergency was detailed by Gen. Lutes at the meeting. Munitions Board interest in standardization problems was among the important points stressed.

A new cataloging agency, he said, is currently formulating rules for naming and describing items. It will develop a system of item identification numbers and provide a commodity classification system suitable for supply management. . . . Also, the Board is developing engineering standards and joint military specifications for end items.

Three major fields of the Board's standards program are: (1) preparation of specifications for use throughout the military establishment; (2) equipment standardization to permit interchanging parts and assemblies; (3) publication of engineering standards acceptable to industry and the military. . . . Hope is to reduce some 12,000 specifications to less than 6000. Sixteen engineering standards are currently under study. Projects in the equipment field include standardization of aircraft equipment, automotive, industrial, and marine engines.

"The automotive engineering profession," Gen. Lutes concluded, "has never failed us. We know that we can count on its assistance now or at any time in the future."

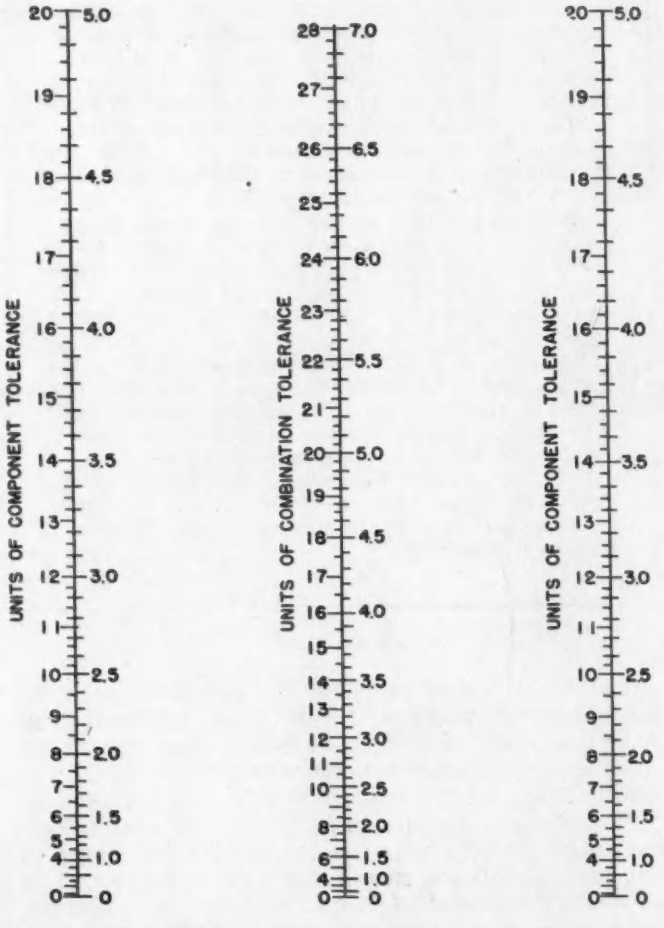
nomic application. The problem will be alleviated, they say, if designers will recognize that "the word 'quality' is most closely allied to performance requirements and only remotely to chemical composition or tensile strength. . . . That there are factors inherent in the word 'quality' as applied to steel which up to now have not been described or defined in numerical values, or evaluated by any test except performance."

Automotive engineers generally disputed the contention that detailed specifications for steels are undesirable and protested any attempt to give steel makers too high a degree of latitude. The automotive men feel they know the requirements of particular jobs in their own area.

A bid was made for designer interest in a relatively new statistical quality control system, data from which, its advocates promised, would permit designers to get larger, but equally satisfactory, tolerances at lower production cost. Detailing possible design opportunities growing out of production department data made available for the Shewhart-type control chart, proponents used SAE Handbook data to illustrate as follows:

For example, take the ½-20 class 3 threads. Pitch diameter tolerance betwen nut and bolt is allowed to vary from size to 0.0052 loose, 0.0026 being allowed as a tolerance for each component.

Connecting 2.6 on both the left and right side of this chart with a straight edge intersects the center line at 3.69.



This means that if our machining equipment could just meet the 0.0026 tolerance on both bolt and nut (with control charts maintaining average size of each at their tolerance range midpoints), assemblies would vary from 0.00075 loose (0.0026–0.00369/2) to 0.00445 (0.0026 + 0.00369/2).

Thus a total of 0.0015 (0.0052–0.00369) or about 35% of the allowed assembly tolerance never would be used for all practical purposes. Carrying this one step further, suppose we take 0.0052 allowed for the assembly.

If we set the straight edge horizontal at this value on the central scale, we would read 0.0037 as from each side scale as the natural tolerance for each component. The SAE Handbook lists 0.0036 as the tolerance for each component of the ½-20, class 2 thread.

So with a control chart, it was claimed, the designer could get class 3 assemblies at class 2 prices.

"Gone would be the days," it was said, "when designers distribute the tolerance load among parts according to empirical rules concerned with the size of the dimension, internal or external dimensions, whether the construction of the work requires a type of milling, single point boring, grinding or the like."

Discussion evidenced considerable interest in the new procedures, but some designers saw it as a system to be currently studied rather than immediately adopted. Agreeing, for instance, that wider recognition and use of the system is desirable, one discusser pointed to limitations. "The theory of the method," he said, "assumes a controlled average and controlled variance of the component parts. To achieve these assumptions in practice requires the designer to specify the allowable variation in average and the allowable maximum standard deviation. The tooling would then have to be chosen to achieve the design intent."

Specific chances for designer cooperation with practically every other department in his plant were stressed in other discussions. The tooling phase of body building, for instance, was called "a happy hunting ground for the body engineer" by one executive, who said: "Wherever a body part, a brace, a panel, a piece of hardware, or a mechanism could be made simpler in design, and still do its job equally well, the design engineer has the opportunity to reduce costs, lighten the tooling load or remove a production hazard. . . . The extent to which he understands the die making, press work, and assembly procedures can greatly influence the efficiency of body-building team-play in this important area."

This same sort of out-of-the-design-groove knowledge helps in controlling the effectiveness of all design engineers in relations with the production planning and management groups, it was emphasized. And the design engineer's influence reaches, and is welcomed in affairs of the traffic and material handling department.

Cited as an example was the engineer who works closely with the purchasing department and develops the many so-called purchase items on a new job with an understanding of the problems of procurement . . . and the one who uses service department experience and reports as "a guide to detailed perfection."

Need to Conserve Fuel and Engine Power Inspires

DESIGN TRENDS

TRENDS reported in design of engines, passenger cars, and small aircraft are in the direction of making the most of the fuels available for power generation and making the most of the power throughout the power train.

Design trends of both diesel and spark-ignition engines are toward getting engines to burn the more plentiful fuels and generate more power from them. Engine builders are turning out stationary diesels that will burn either gaseous fuels with only a pilot charge of oil, or all oil.

For passenger-car engines, engineers are considering addition of water-alcohol mixtures to the fuel charge and increases in compression and expansion ratios.

Further along in the power train, there are new trends in transmission of power from engine to passenger car wheels and in absorption of power in small aircraft—trends in the direction of conserving power once it is generated.

The trend in American passenger car transmissions is toward torque converters, according to one observer. In small aircraft, the tendency is to install more efficient propellers and reduce drag of structures.

Although no trend in helicopter rotor arrangements is apparent yet, a helicopter expert pointed out that all current configurations give some, though not all, the desired characteristics.

The dual-fuel diesel engines developed during the last four years to burn either a gaseous fuel with only a pilot charge of fuel oil or all fuel oil will account for a considerable percentage of future diesel production, a diesel engineer predicted.

This new type of engine is a boon to users of diesels for industrial power in areas where gas is available, he explained. Only about 5% of the total Btu's at full load need be supplied in the form of liquid fuel. The rest can be cheaper natural gas, refinery gas, manufactured gas, propane, or even sewage gas.

If the gas supply fails or runs low, the consumer can switch immediately to all oil, a feature that often gives him lower price rates from his gas supplier.

The most modern versions of the dual-fuel engine contain the gas supply in the cylinder during compression. On a 4-stroke-cycle engine, this designer said, good results have been obtained simply by admitting the gas continuously into the air intake valve passages.

With 2-stroke-cycle engines, the gas is admitted directly to the cylinder under 25 to 50 lb pressure to get the gas in quickly between the closing of the exhaust ports and the build-up of compression pressure.

With supercharged 4-stroke cycle engines, where scavenging is vital, gas injection must be timed so that fuel is not lost in the scavenging, but injection into the air-intake passages seems to give better mixing than injection into cylinders, he said.

Based on discussions and five papers presented at one Aircraft, one Diesel Engine, one Passenger Car and one Truck and Bus session. . . . "Personal Aircraft Problems and Progress," by **Herb Rawdon**, Beech Aircraft Corp.; "Today's Picture in Helicopters," by **R. H. Prewitt**, Prewitt Aircraft Co. . . . "Status of Dual-Fuel Engine Development," by **R. L. Boyer**, Cooper-Bessemer Corp. . . . "Is the Torque Converter Going To Be It"? by **O. K. Kelley**, General Motors Corp. . . . "Petroleum Scarcity and Cost Increases," by **R. J. S. Pigott**, Gulf Research and Development Co. . . . **All of these papers will appear in abridged or digest form in forthcoming issues of the SAE Journal, and those approved by Readers Committees will be published in full in SAE Quarterly Transactions.**

His performance figures highlighted the efficiency of the 4-stroke-cycle designs:

One atmospheric dual-fuel engine produces a horsepower-hour for 6800 Btu at full load and 11,000 Btu at one-quarter load. A supercharged engine gives a horsepower-hour for 6400 Btu at full load and for 9000 Btu at one-quarter load. At full load, brake thermal efficiency of the supercharged engine is 40%.

Discussion turned up even lower figures for a particular 2-stroke-cycle engine.

Interest in the dual-fuel idea was apparent among the builders of smaller, high-speed diesels, too. But its application to their engines is complicated by the greater range of engine speeds and the higher compression ratios, they explained.

In the field of spark-ignition engines, engineers explored means of burning readily available gasolines of moderate octane level at increased compression ratios to get more power from a given amount of petroleum.

Raising cylinder compression ratios affords worthwhile operating gains, but requires higher octane levels than are likely to be available in large volume, an oil man pointed out.

Two ways of getting around this difficulty were aired.

One was the resort to dual fuels. It was reported that compression ratios of 8:1 or maybe higher can be handled by supplementing commercial gasoline with 4–5% alcohol and water for peak octane demand. This method will soon receive full-scale commercial trial, chiefly for trucks.

Or the design trend may turn toward the other method suggested—breaking compression into two stages and cooling between stages. The first stage of compression can be accomplished in a supercharger, then the charge cooled before entering the cylinder for the second stage of compression. The cooling lowers octane requirement because detonation is more the result of high temperatures than high pressures, it was explained.

Continued on page 66

(This paper will be printed in full in SAE Quarterly Transactions)

How the Torque

EASIEST way to understand the torque converter is to reduce its operating principle to simple comparisons with familiar mechanics of the flywheel. We must start with an explanation of the fluid drive coupling before we can understand how the torque converter works.

The simple mechanics of hydrokinetic drive (fluid drive coupling) begins with the mechanics of a spinning flywheel. See Fig. 1. A spinning flywheel

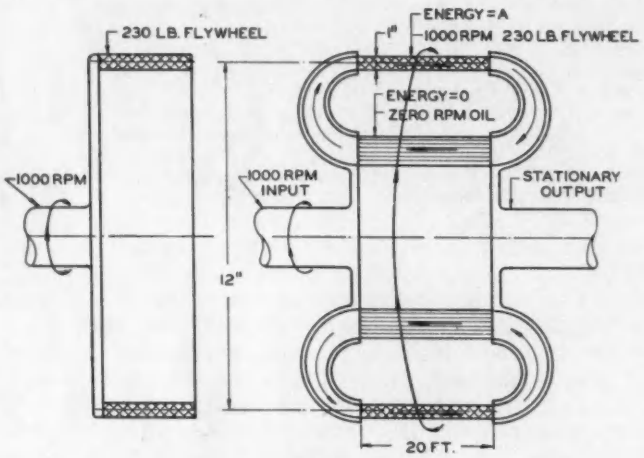


FIG. 1

has stored up energy; if it is stopped it will exert a force on the mechanism stopping it. Conversely, a force must be exerted against it to get it up to speed again after it has been stopped. A fluid drive coupling with an engine driving the input member and the output member stalled is the direct equivalent of this principle.

Oil flowing radially outward through the input member—really a centrifugal pump—leaves the member in the form of a spinning flywheel made of oil. Force exerted by a flywheel depends on the rate at which it is stopped, its mean diameter, and its weight.

Input member of the fluid drive coupling pictured above extrudes out of its outlet a 1000-rpm flywheel, with a 12-in. mean diameter and 1-in.-thick rim section, at the rate of 20 fps. A 20-ft length of this weighs close to 230 lb. You can visualize the force exerted on the mechanism that stops one of these flywheels every second. This is what goes on in the fluid drive coupling at stall . . . back of a 190-ft-lb torque engine running full throttle, trying to start the car.

The engine-driven member is extruding a spinning fluid flywheel and pushing it into the teeth of the stationary driven member, which stops the spin and gets a force on its vanes equal to a torque of 190-ft-lb.

Once the oil gets inside the vanes of the stationary member, all resemblance to a spinning fluid flywheel is destroyed; the oil merely comes out in straight axial flow, back into the input member. There the oil is picked up from standstill and recreated into a spinning fluid flywheel by the input member. An equal force then must be exerted by the engine against the oil while this is being done.

If we examine the action of a fluid drive coupling running efficiently at higher speed, we recognize another direct comparison with flywheels. Let us assume two flywheels, each running at 1000 rpm, each weighing the same, but having different mean diameters, as in Fig. 2. While the larger diameter

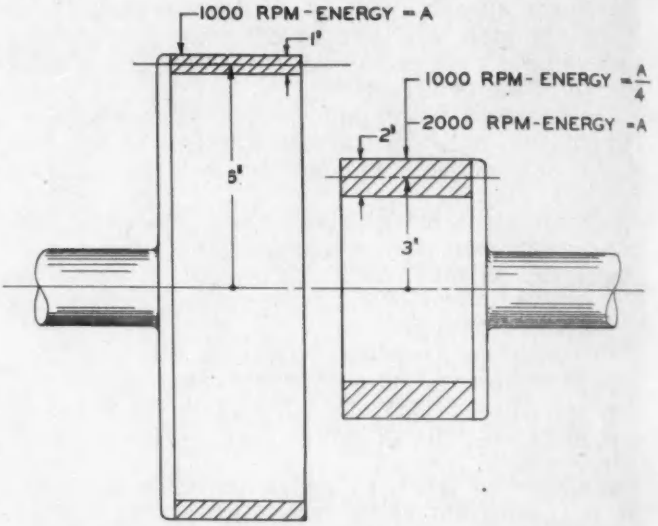


FIG. 2

flywheel weighs no more than the small one, obviously it is more of a flywheel. If the diameter of the larger one is twice that of the smaller one, it is really four times the flywheel though it weighs no more.

From this relationship we can draw two basic facts. First, the larger flywheel contains four times the energy of the smaller one, though both weigh the same and run at the same speeds. Second, to have the same energy in both flywheels, the smaller would have to run twice as fast as the larger one.

Now suppose we could take this larger flywheel running at 1000 rpm and efficiently extrude its metal down to the diameter of the smaller one, still running at 1000 rpm. The process would then leave in our hands a bundle of energy . . . the energy difference between these two flywheels. This would leave us with three-quarters of the original of the large-diameter flywheel to take care of together with the small-diameter flywheel—weighing the same and spinning at the same speed.

Such extrusion process would be difficult in metal, but is a natural in oil. This is exactly what goes on in the fluid coupling drive while it is running near 100% efficiency. See Fig. 3.

Assuming 100% efficiency, we would see the input member producing a continuous fluid flywheel at so many feet per second, the driven member acting as an extrusion die and squeezing it down to a smal-

Converter Works

BASED ON PAPER* BY

Oliver K. Kelley

Engineer in Charge of
Transmission Development
GENERAL MOTORS CORP.

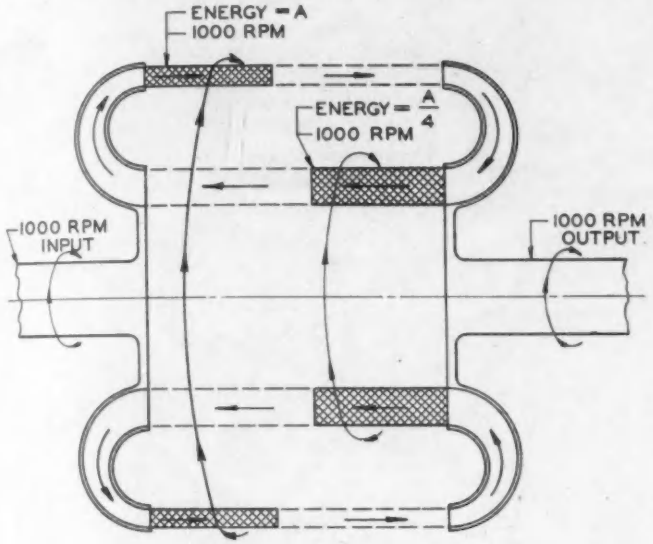


FIG. 3

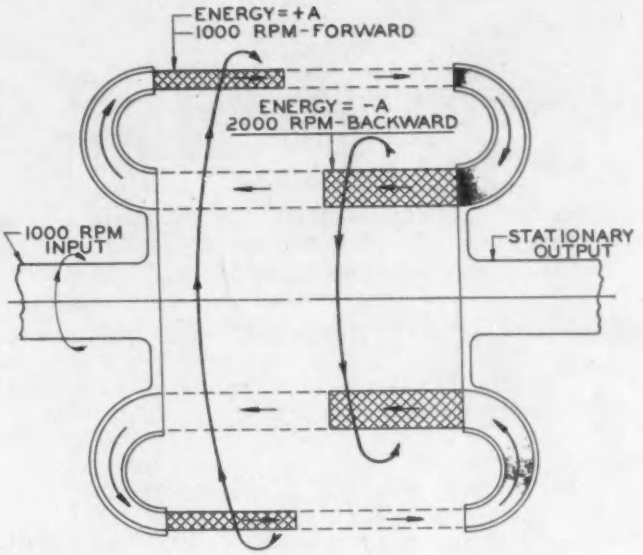


FIG. 4

ler diameter, and a heavier rim section flywheel coming out of the exit of the driven member at the same rpm at which it went in—but minus three-quarters of its energy. This three-quarters of the original energy drives the car; it also must be supplied by the engine when the flywheel diameter is extruded upward into a larger size again in the input member.

We can picture the fluid drive coupling in its efficient driving range as a pair of rotating extrusion forms playing a game with the oil—making a large-diameter spinning flywheel into an equal weight small-diameter spinning flywheel and vice versa, ad infinitum. The output member absorbs energy as the flywheel diameter decreases and the input member spends an equal amount as flywheel diameter increases.

We don't have too far to go from here to a simple three-element torque converter, in Fig. 4.

Assume 100% circulation efficiency and let us take the input member from the fluid drive coupling, just as it was, and run it at 1000 rpm with the output member stalled. But let us replace the straight vanes of the fluid drive coupling with strongly-curved vanes in the output member. We shall make the curved entrances receive this spinning oil mass with 100% efficiency by properly bending the vanes to receive the spinning oil without splash. Exit of the vanes is curved strongly backward. This means the oil finally extruded out of the turbine now is spinning backward . . . it is a backward-spinning flywheel.

Its backward speed depends on exit angle of the vanes and flow velocity of the oil. Let us assume that 20 fps is a high enough flow rate and that the vanes have a strong enough back bend so that the outcoming oil has a spinning speed of 2000 rpm. The smaller flywheel running at 2000 rpm has the same energy as the larger flywheel running at 1000 rpm.

If the turbine is standing still and the vanes have done their work on the oil with 100% efficiency, it would be possible to have equal energies in input and output oils, but in opposite directions.

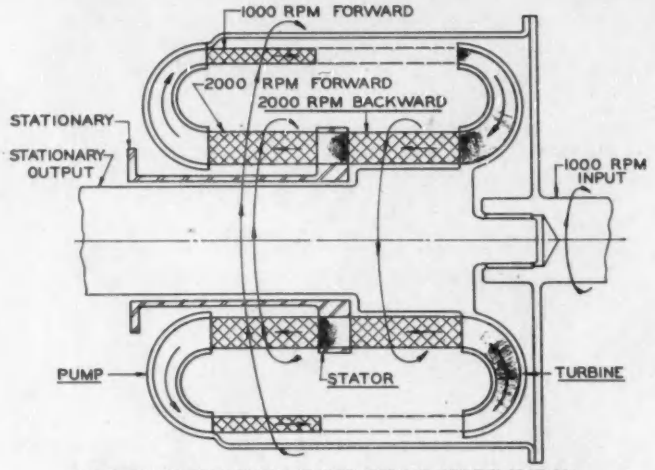
Now the force felt by the turbine is obviously a lot greater—just twice as great as in the fluid drive coupling at stall if the input member is sending out an equal fluid flywheel, at 20 fps. The turbine feels the force of slowing down the 1000 rpm fluid flywheel rim section at a rate of 20 fps; it also feels the reaction of speeding up the backward-spinning flywheel of equal energy. Thus it feels twice the force of the fluid drive coupling turbine for equal flow velocity and equal input conditions.

But there is one thing seriously wrong with this arrangement—the direction of the backward spinning oil leaving the turbine. It would require the entire engine torque just to stop this backward rotation when it hits the entrance to the input member; and there would be nothing left to get the oil re-energized into a forward-rotating flywheel at the outlet of the input member.

It is not too difficult to correct this situation. All

* Paper "The Polyphase Torque Converter," was presented at SAE Philadelphia Section, Oct. 13, 1948. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.

we must do is install a set of curved stationary vanes between the turbine exit and the pump entrance, as in Fig. 5. These vanes must be properly



100% FLOW EFFICIENCY-INFINITE TORQUE MULTIPLICATION
FIG. 5

shaped to receive the backward rotation, bring it to a stop, then direct it to forward rotation.

If this is done without loss, by having a very efficient arrangement of vanes in the stationary member, we still will have no energy loss in the oil as it leaves the stator. The stator merely has received a fluid flywheel running backward at 2000 rpm, brought it to stop, then let it convert itself to a forward-rotating fluid flywheel at 2000 rpm. This action is very similar to what took place in the turbine.

Let us focus on the action of this conversion from one direction of rotation to the opposite direction. Bear in mind that the flywheel effect of any spinning body is really the sum total of the momentum of all its particles due to their speed and that momentum is not lost if speed is not lost. Thus we see that as the oil is slowed down in its rotation by the vanes, when all its rotation is stopped, it really is accelerated into an axial flow without losing its speed.

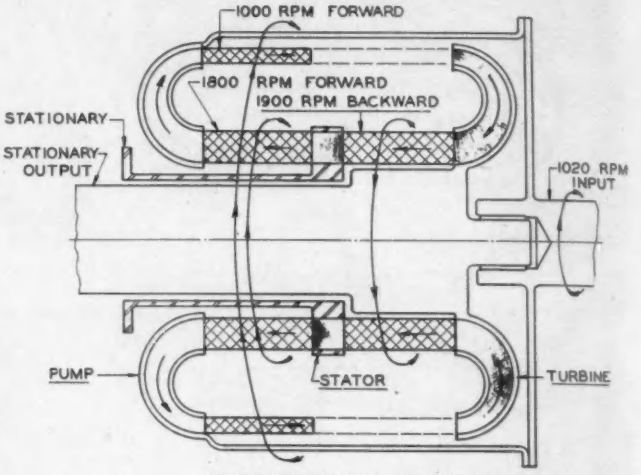
This same absolute velocity then is directed by the vanes into a new rotary direction; as the oil leaves the vanes, it is once again a fluid flywheel of the same speed, but different direction of rotation.

Now let us see what happens when this oil reenters the pump. We note that the entering oil in the form of a smaller-size flywheel running at 2000 rpm has the same energy, and in the same direction, as the larger-size 1000-rpm flywheel coming out of the pump. This means that the engine does not add any energy to it at all. The engine-driven pump could be designed with properly shaped vanes to receive the 2000-rpm smaller flywheel, let it expand in a free whirl into the larger-diameter flywheel section and slow down in its rotation as it expands (natural behavior of liquids in free whirl) until it comes out of the pump at 1000 rpm—hardly having touched the vanes.

Theoretically we could get a big driving torque on the turbine without taking any torque at all from the engine! Such would be the case if there were no flow losses. With 100% efficient flow we would have perpetual motion. But as with all perpetual motion machines, friction is the "fly in the ointment."

And there is friction in fluid flow also. It would be impossible to achieve such an ideal because of the losses in extruding a larger-size oil flywheel to a smaller size. The fluid drive coupling never can be 100% efficient. Part of the momentum of the 1000-rpm larger flywheel is consumed in overcoming friction of flow.

The same holds true here. Part of the momentum of the larger 1000-rpm flywheel (and a greater part now is needed) must be used to make the conversion through the turbine. See Fig. 6. Thus we would be



19.5 TO 1 TORQUE MULTIPLICATION
FIG. 6

fortunate to get a 1900-rpm backward-spinning flywheel in place of a 2000-rpm one; and we had better design the vanes for that.

Similarly, the same kind of losses face us going through the stator. The best we could do is design the stator exits to produce an 1800-rpm flywheel running in the right direction from our 1900-rpm backward-spinning flywheel. This has the energy equivalent of a 900 rpm larger flywheel. But even this 900 rpm would not materialize in the larger diameter without some help from the pump. However, the pump vanes can be slanted slightly backward; this permits the pump to run slightly faster—say at 1020 rpm—while the back bend of the vanes urges the flow on.

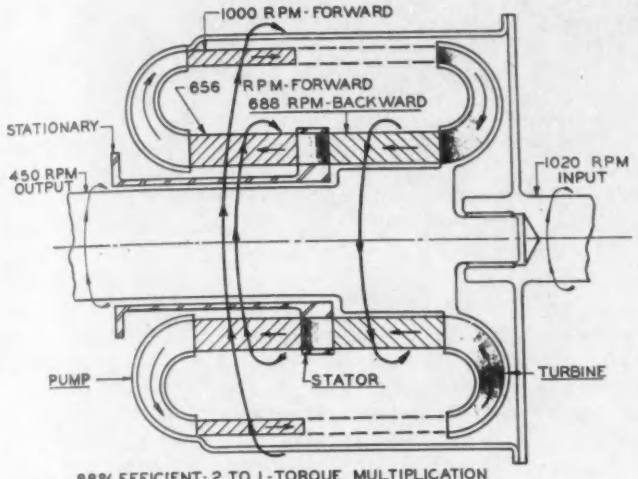
This does not increase the torque on the pump, only its speed. And the pump will feel the torque equal to the difference between the original 1000-rpm flywheel and the 900-rpm equivalent of the small-diameter flywheel entering the pump.

Using energy equivalents of the larger-size flywheel, we can say that the turbine has felt the push of the 1000-rpm flywheel plus a 950-rpm flywheel. This is the equivalent of the small-diameter 1900-rpm backward-rotating flywheel. It would add up to an index figure of 1950 rpm representing turbine torque. Pump torque could be represented by the 100-rpm figure. And stator torque would be the equivalent of 1850 rpm in the larger-size flywheels—the sum of 1900 and 1800-rpm small diameter flywheels.

Perhaps we could make a torque converter where the relation of turbine torque to pump torque is near 20 to 1 if we designed the converter for maximum flow efficiency at stall—when the turbine is standing still. But if the turbine is standing still, it does no work and overall efficiency is zero. It

would not pay to design for this condition, except for a maximum torque multiplication demonstrator to show that it can be done.

A practical torque converter must be designed with vane entrance angles that receive the flow properly at some useful drive ratio—say a 2 to 1 torque multiplication. See Fig. 7. If we assume the same con-



88% EFFICIENT-2 TO 1-TORQUE MULTIPLICATION
FIG. 7

ditions of flow velocity and efficiency, here again we must assign a loss through the turbine equivalent to 50 rpm in terms of the larger-size flywheel and an equal loss for the stator. Thus by the time the oil gets back into the pump, there is a total equivalent of 100 rpm lost of our original 1000 rpm flywheel energy just for hydraulic flow losses through turbine and stator.

Computing Turbine Speed

Additionally we have to contend with turbine rotation. If hydraulic flow through the turbine and stator involves a 10% energy loss, obviously turbine speed must be 10% less than one-half the pump speed if turbine torque is to be twice pump torque. This sets turbine speed at 450 rpm. The turbine vanes should be formed to properly receive the 1000-rpm oil when the turbine is running at 450 rpm. Next we must resort to simple arithmetic to find out how the turbine exit angles are to be formed.

Hydraulic loss assigned to the stator equalled 50 rpm of our 1000 rpm initial energy. This is 5%. We can say that rotational speed of the oil before the stator should be 5% greater than after the stator. Let us designate as X the rpm of the oil as it enters the pump and as 1.05X the rpm as it leaves the turbine.

We know that pump torque is the difference in flywheel values before and after passing through the pump, and that turbine torque is the sum of flywheel values before and after passing through the turbine. One must be twice the other, so that our equation is:

$$2\left(1000-\frac{X}{2}\right)=1000+\frac{1.05X}{2}$$

$$X=656$$

$$1.05X=688$$

We must design the turbine exit angles to produce a net backward spin to the oil of 688 rpm, while the turbine itself has forward speed of 450 rpm. This means that the turbine exit angles must produce a reverse spin of 1138 rpm instead of our ideal stall ratio torque converter's 1900 rpm.

The 2% loss for the pump member must be taken care of as before and again a slight back bend provided in the pump vanes so that the 1000 rpm initial energy flywheel would come out of 1020 rpm speed. This would complete our design and we could add things up to compute our overall efficiency. Taking the pump speed times its torque, and dividing by the turbine speed times its torque, we have an overall efficiency of 88%. This is the so-called design point efficiency where there is ideal flow, without any entrance shock losses.

Effect of Losses

This converter with turbine stalled cannot produce 20 to 1 torque multiplication. It differs from our ideal converter in two important respects.

First, its members are not receiving the oil properly when the turbine is stationary. They were not designed for that. Large shock losses are encountered which increase flow resistance. Second, its turbine and stator are not designed to accomplish the maximum possible turning of the oil as was done in the ideal stall ratio converter. The turbine vanes now produce a backspin of 1138 instead of 1900 rpm. The stator vanes now produce a forward spin of 656 rpm instead of 1800 rpm.

More oil must circulate through this milder path to produce the same forces in the turbine; and the pump must exert a greater torque on the oil since the stator no longer is producing the maximum possible forward spin for the pump.

Both shock losses and ordinary circulation losses are proportionate to the square of flow velocity; this adds up to several times the losses of the ideal stall ratio converter. We possibly would get 6 to 1 torque multiplication out of this converter if everything were at the optimum.

A similar situation on losses, only worse, exists at higher speed operation. All the angles would be wrong, in the opposite direction, and the shock losses would cut into efficiency very rapidly. This is the shortcoming of torque converters of this single phase design. Their efficiency is good at the design point and their torque multiplication adequate at stall; but their high-speed efficiency suffers so much that this design is impractical.

What the torque converter needs is a constantly changing entrance angle for its members to adapt themselves to ever-changing conditions as turbine speed varies. We have yet to see a practical mechanism that achieves this in infinitely variable form, which would be the ideal design.

The new General Motors polyphase converter—used in the Buick Dynaflow—is a commercial solution to the problem. It makes the most vitally needed corrections to the entrance angles of its members. Three modifications to the entrance angles are made in this design. These three corrections together with the original starting setup gives four phases of operation. The simple converter has merely its original starting phase and is called a single phase converter.

Control

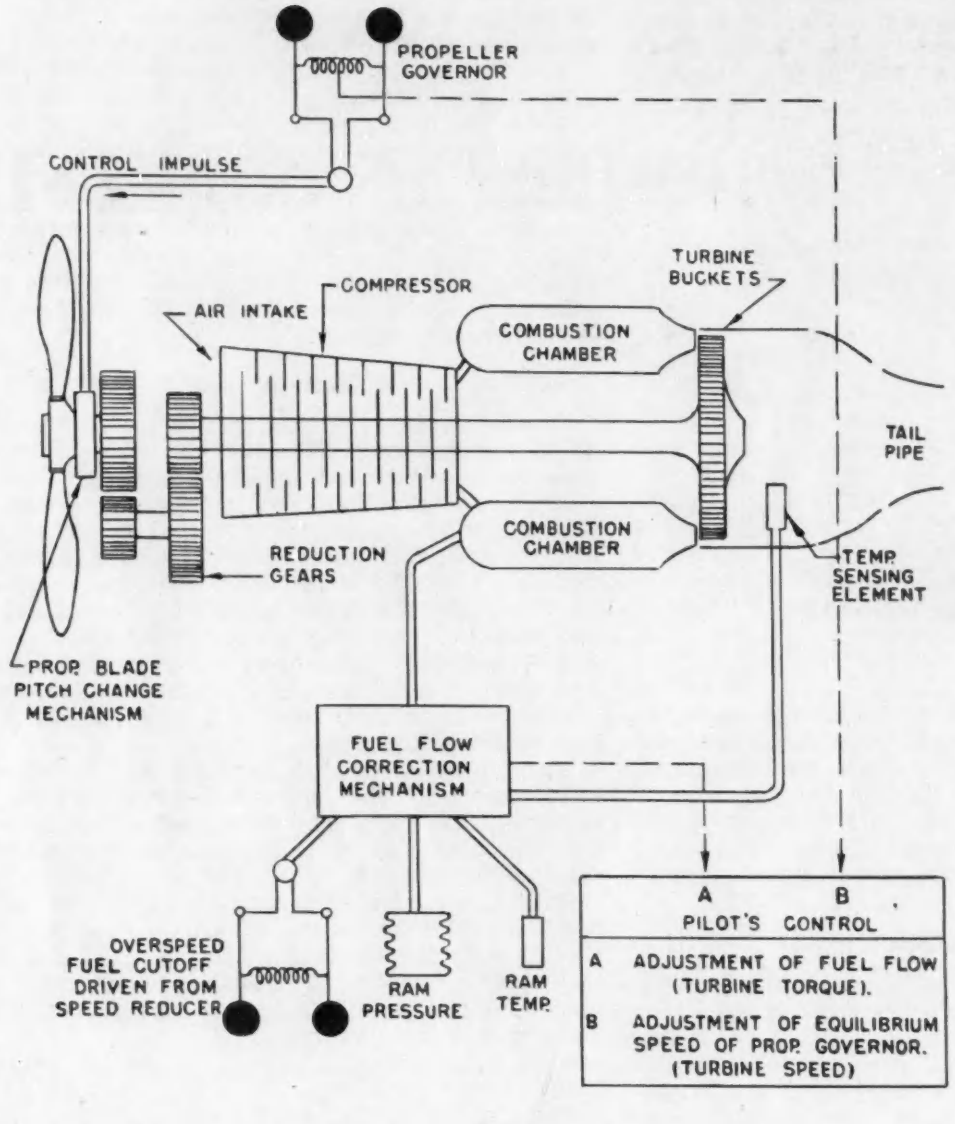


Fig. 1—Control configuration for turboprop

COMBINING a gas turbine powerplant and a propeller in an airplane imposes a number of requirements on the propeller control besides the fundamental one of enabling the pilot to select a desired value of powerplant thrust for each flight condition.

The two basic variables to be controlled in the gas turbine-propeller combination are rotational speed and turbine temperature. And there are two basic control parameters—propeller pitch and fuel flow. Control of the two variables through the two parameters must be arranged so that the gas turbine operates within its stable operating range, the control system itself is stable, and the rate of change of propeller pitch varies with the demands of flight conditions.

Either variable can be controlled by either parameter. Fig. 1 shows a powerplant-propeller combination in which a rotational speed governor instigates changes in propeller pitch to maintain the

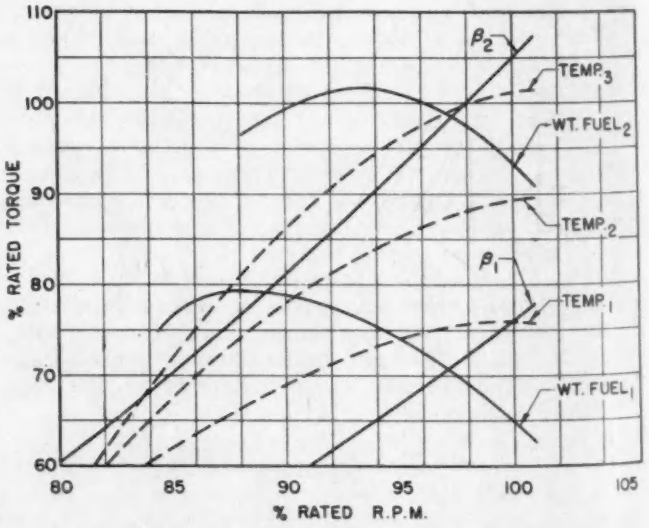


Fig. 2—Propeller and gas turbine powerplant speed-torque relationships

Requirements for Turboprop Propellers

BASED ON PAPER* BY

R. C. Treseder

Aeroproducts Division, GMC

desired rotational speed. This is similar to the constant-speed propeller control used with reciprocating engines. A temperature-sensitive control instigates changes in fuel flow to maintain turbine temperature at the preselected value. Because of the expected time lag in such a control, the temperature is synthesized by simultaneous measurements of ram pressure, temperature, fuel flow, and rotational speed. Such a synthesis will have some unavoidable errors, so it is constantly trimmed by a measurement of actual gas stream temperature.

Making a large change in one parameter without a corresponding change in the other can be dangerous. Fig. 2 shows one reason why. Decreasing rpm in the low torque range would increase temperature markedly, maybe to the point of overtemperature.

Because of the interaction between fuel control and propeller pitch control under most operation conditions, it will be desirable to operate both fuel and propeller controls from a single handle and to restrict those combinations of fuel flow and propeller pitch that produce unsafe or uneconomical operation.

Fig. 3 shows the safe limits of operation for the turboprop. Although the propeller is capable of operating safely anywhere within the limits of the turbine, except at the negative thrust that might be experienced at negative angles of attack at high forward velocities, the stable operating range of the powerplant is limited by high centrifugal forces on its rotating parts, high temperatures, instability of the compressor at low rotational speeds, and burner dieout when the turbine is forced to absorb power.

The desirable part of the safe operating range from the point of view of power output and fuel economy is the high-rpm, high-temperature area.

What happens to propeller speed and torque if fuel setting is increased suddenly for a reciprocating engine and for a turboprop is shown in Fig. 4. It represents a typical take-off condition with the propeller's constant-speed control operating. For the reciprocating engine, there is a sudden overspeed, which is soon reduced by the constant-speed control. The torque increase is small—the excess propeller torque over that being supplied by the engine is provided largely by the kinetic energy of the rotating propeller. The polar moment of inertia of the propeller is many times that of the engine, so transfer of rotational kinetic energy into propeller torque is accomplished without transferring much torque through the reduction gearing.

If this same propeller and its associated speed-sensitive governor were installed on a typical turboprop with the control configuration shown in Fig. 1, speed and torque would oscillate in quite a different manner. The initial slope and the magnitude of the overspeed would be less because of the greater rotational inertia of the turbine-propeller combination. But both speed and torque would overshoot desired values. Not only does turbine torque spurt because of the increase in fuel and rpm setting, but also the excess energy supplied when the constant-speed control decelerates both the turbine and the propeller shows up as torque increase, enlarging the amplitude of the torque oscillation.

Although the moment of inertia of the recipro-

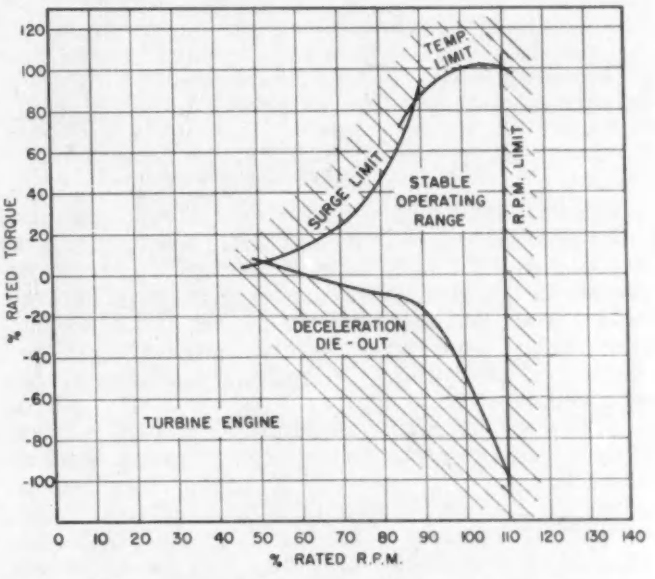


Fig. 3—Typical gas turbine powerplant operational limits

* Paper "Controls for Gas Turbine Propellers," was presented at SAE National Aeronautic and Air Transport Meeting, New York, April 15, 1948. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.

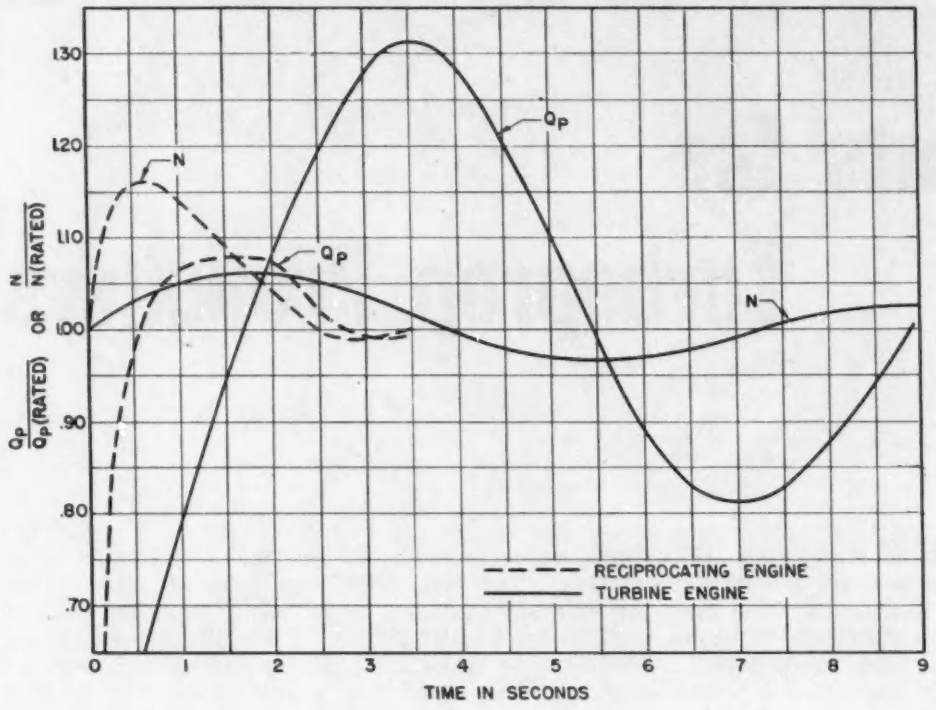


Fig. 4—Propeller speed and torque oscillations following a powerplant torque change

cating engine is much less than that of the propeller, the moment of inertia for the gas turbine powerplant is much greater than that of the propeller because of the rotating masses. Since for a given deceleration, the resulting increase in torque is proportional to the moment of inertia, the torque increase for the turbine powerplant will be very large, much larger than the torque increase of the propeller, and the powerplant torque will be transmitted through the reduction gearing to the propeller. Upswing in turbine-propeller rpm will be reflected in decreases in thrust.

Propeller thrust oscillation, proportional to and in phase with the torque oscillation, will be transmitted to the airplane. And since turbine blade temperature is inversely proportional to speed, the temperature will oscillate 180 deg out of phase with the speed oscillation. The seriousness of torque and thrust oscillation has been born out in test flights.

Controls Must Add Damping

Constant-speed propeller controls for turboprop use should contain sufficient artificial damping to compensate for this lack of natural damping inherent in the gas turbine powerplant-propeller system. The natural damping can be augmented by making the time rate of pitch change proportional to both offspeed and acceleration, instead of merely offspeed.

This type of artificial damping is critical with time lag in the propeller control. The lag becomes more and more undesirable as speeds increase because the change in propeller torque due to a change in pitch increases. If the lag is great enough, the effect of the artificial damping may be destroyed, and the speed oscillation can become divergent.

Since the magnitude of the acceleration is rather small and difficult to measure, it is sometimes better to change propeller pitch in accordance with the difference between the instantaneous and equilibrium shaft torque, rather than with rotational off-

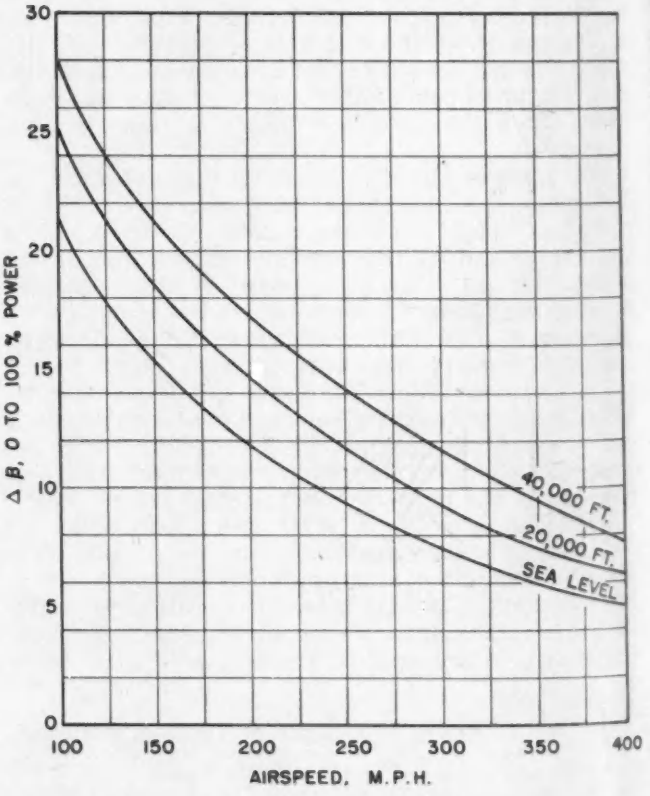


Fig. 5—Change in pitch required for 100% power change

speed and acceleration. (The torque difference is proportional to the torque available for acceleration.) Such a control requires a torquemeter between the turbine and the propeller, but it exhibits well damped response.

Constant-speed controls for reciprocating engines incorporate stops in the pitch-change mechanisms which give fixed-pitch operation for the landing regime. But with the turboprop, it is not possible to operate the propeller in fixed pitch and vary turbine rpm to obtain thrust control because of the turboprop's large inertia, small amount of accelerating torque at low speed, and the limited speed range. Fixed-speed operation appears to be more practical. This requires the propeller control to reverse its sense at some low blade angle, the absolute value of which is a function of airspeed. The reversal of sense is required whether the control senses speed, temperature, or torque.

One solution would be to use the constant-speed control for those forward velocities and blade angles where propeller torque increases with an increase in blade pitch, and to use for taxiing and reverse thrust a fuel governor to maintain a preselected rotational speed while the pilot controls blade angle directly. Such a control could be used only during the landing and taxiing regime because it is extremely sensitive at higher airspeeds.

Pitch-Change Needs Vary

In comparison with reciprocating engines, turboprops require a higher rate of pitch change at some times and a lower rate at others. After an interrupted landing, the pilot needs to be able to obtain maximum thrust rapidly. The turbine is already operating close to maximum rpm. Therefore, the increase in thrust must be made by increasing pitch, and increasing it fast. But, as Fig. 5 shows, much less change in pitch is needed for power increase at higher airspeeds. Where pitch change is more critical, lower rates of pitch change are desirable.

Rate of pitch change under feathering conditions is dictated by permissible gear box loads rather than by propeller thrust loads. If propellers on turboprop airplanes were feathered at the rate of pitch change used with reciprocating engines, peak torques would reach 170% of rated gear box values. Propellers for turboprops must be feathered at a considerably slower rate.

A failure of the pitch change mechanism that would permit the propeller to drift toward low pitch would be very dangerous, even at moderate forward velocities. At 400 mph, a change in blade angle of less than 10 deg could change turbine loading from rated torque in the positive direction to rated torque in the negative direction. At medium or high velocities, the drag of a windmilling propeller that remains connected to the turbine will approximately equal in magnitude the rated positive thrust under the same conditions. The available energy in a high-velocity airstream is so great that a windmilling propeller can drive a turbine in excess of its rated rotational speed even with the fuel shut off. These facts indicate that the need for reliability in feathering systems is even greater with turboprops than with reciprocating engines.

Industry Faces Steel Shortage

Based on paper by

JOSEPH GESCHELIN

Detroit Editor,
Automotive Industries

ALTHOUGH 1947 automotive production fell short of early optimistic estimates, vehicle producers flashed a miracle of performance in meeting the challenge of shortages and disappointments.

Vehicle companies acquired interest in steel mills, organized scrap steel drives, and effected substitutions on a scale never attempted before in peacetime.

Purchase of the Chapman-Price Steel Corp., Indianapolis, by Kaiser-Frazer Corp. secured sheet for floor pans and reinforcing strip for Kaiser and Frazer cars. Earlier acquisitions in steel-making facilities had been investment in the formation of the Portsmouth Steel Corp. in that Ohio city, lease of a blast furnace at Struthers, Ohio, and purchase of a modern gray iron foundry at Dowagiac, Mich.

Studebaker Corp. purchased the Empire Steel Corp. at Mansfield, Ohio, a plant with annual capacity of 348,000 tons of ingot and 120,000 tons of hot rolled sheet.

Hudson Motor Car Co. leased two-thirds of the capacity of the former Shenango tin plate plant of Carnegie-Illinois in Pennsylvania, anticipating 100,000 tons a year of rolled steel sheet.

In 1946 three independent suppliers of Packard Motor Car Co. were acquired by new owners, and that company was forced into complicated deals involving purchase of slabs and billets from one group of sources and shipping them to rolling mills for finishing.

In the area of substitutions some applications proved to be economical, some broke even on cost, but the majority cost more. In general, substituting aluminum for steel was a case of immediate expediency rather than engineering economy. The blunt fact proved to be that aluminum was as tight as steel because a basic ingredient in the light metal is electricity—which was scarce.

The example of what Ford Motor Co. did in substituting aluminum for steel in small parts was an interesting one. A study by the author disclosed that the program resulted in saving about 58 lb in the Ford and about the same in the Mercury.

The largest single piece was the floorboard extension which when made of steel weighed 15.2 lb. Its aluminum counterpart weighed 6.8 lb.

Fifteen parts, including the above, totaled 25.27 lb of aluminum and saved 57.38 lb of steel. (Paper "The Steel Situation—Its Effect on the Automotive Industries" was presented at SAE Detroit Section, May 17, 1948.)

Additive-

IN its constant search for improved crankcase lubricants, the petroleum industry has passed through several important stages of lube oil improvement. This search has been activated, to a considerable extent, by the ever-increasing severity of operating conditions and by the expanding appreciation of higher performance standards by many consumers.

Considerable emphasis has always been placed upon crude oil selection for lubricant manufacture and, with early refining techniques, this selection was of greatest importance. Such careful selection of crudes, although of lesser importance than formerly, still cannot be disregarded by the producer or consumer of lubricants.

During the last two decades, primary consideration was placed upon the development and perfection of new refining methods, such as solvent extraction, propane deasphaltizing, and solvent dewaxing. Through these new refining procedures superior lubricants were provided in large volume. However, in certain types of service these newer lubricants possessed deficiencies such as corrosiveness toward certain alloy bearing metals and the tendency to form objectionable piston and ring deposits.

To improve still further the performance of these highly refined lubricants, selected chemical compounds, called "additives," were blended into many crankcase lube oils. In recent years, whenever a new lubricant problem arises, one of the major tools for providing a superior solution lies in a consideration of carefully selected additives blended into a well refined petroleum lubricant from selected crudes.

Table 1 gives chronologically the major developments in improvement of crankcase lubricants since 1920.

Additives are employed in crankcase lubricants to: (a) Reduce the necessity for expensive refining

Table 1—Crankcase Lubricant Developments from 1920 to Date

		Improvement in Lubricant	
Date	**Reason for Development**	**Refining Process**	**Additive**
1920	Reduction of friction		Oleic acid
	Low-temperature oils needed	Drastic dewaxing Solvent dewaxing	
1930	Lower pour-point oils	Improved vacuum distillation	Pour-point depressants
	Lower sludging and higher V.I. oils	Solvent extraction	
		Hydrogenation	
	Improved V.I.		V.I. improvers
	Alloy bearings introduced		Corrosion inhibitors
	Reduction in diesel engine deposits desired		Detergents
		Propane deasphaltizing	
		Propane dewaxing	
	Caterpillar adopts copper-lead bearings		Heavy-duty oils containing additives to give combination of high degree of detergency and corrosion inhibition
1940	Army Ordnance adopts heavy-duty oils for ground vehicles (2-104B)		
1947			Premium-grade passenger-car lubricants containing oxidation and corrosion inhibitors
1948	High-sulfur diesel fuel		Series 2 diesel lubes for high-sulfur fuels
			High concentration of additives to give very high detergency, together with corrosion inhibition

Treated Crankcase Lubricants

EXCERPTS FROM PAPER* BY **C. F. Prutton** Carl F. Prutton & Associates, Inc.

Fig. 1—Effect of additive treatment on blowby in Caterpillar diesel engine

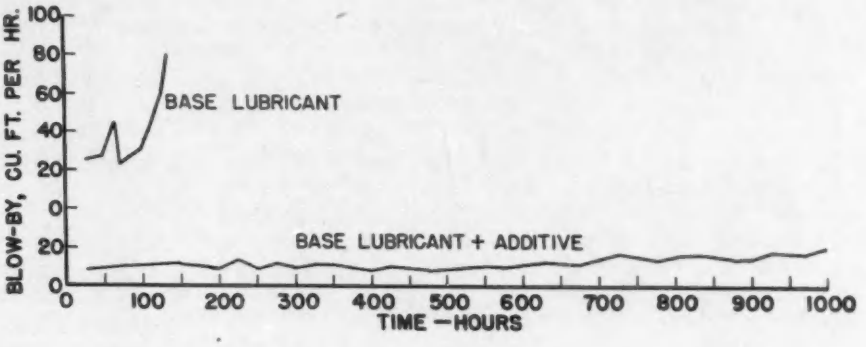
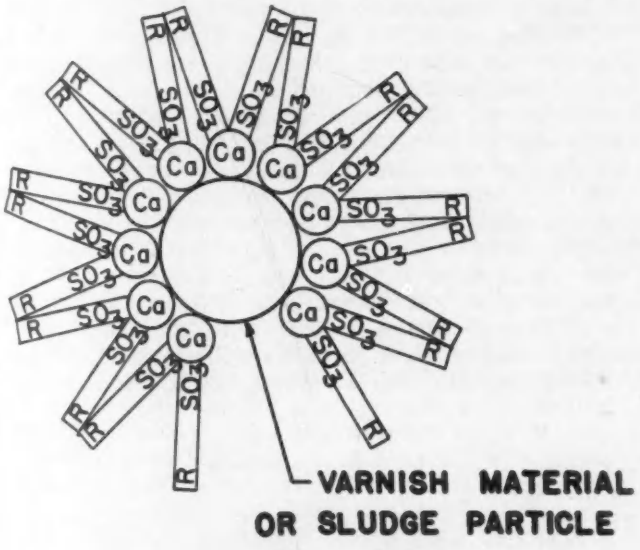


Fig. 2—Adsorption detergency action



procedures. For example, pour-point depressants make drastic dewaxing unnecessary in the preparation of lubricants for low-temperature service.

(b) To improve certain desirable properties of the mineral oil in ways or to an extent that improved refining methods cannot effect. Detergent additives may be used largely to reduce piston and ring deposits; antioxidants reduce the deterioration of the lubricant due to oxidation, and corrosion inhibitors retard bearing and other metallic corrosion. Additives for reduction of friction coefficient for the increase of film strength, pour-point depressants, and viscosity index improvers have also been employed in crankcase oils. Many single additives are multifunctional, improving several properties of the lubricant.

Early in the 1930's crankcase lubricants containing detergents were developed mainly for Caterpillar diesel-engine use. By reducing piston and ring deposits these additive-treated oils greatly extended periods between engine overhaul, and soon proved their great value in the field (Fig. 1). The early detergents employed included calcium, barium, and aluminum soaps, which gave excellent service when babbit bearings were used but which were not satisfactory for use with copper-lead and certain other alloy bearing metals.

About the same period, the partial introduction of copper-lead and cadmium-alloy bearings in gasoline engines brought corrosion difficulties with it. Corrosion inhibiting additives were found to be an adequate solution to this problem.

In 1937 when the Caterpillar Tractor Co. changed from babbit to copper-lead bearings, it became necessary that crankcase lubricants for this service possess adequate bearing corrosion inhibiting qualities, as well as a high degree of detergency.

In most of these heavy-duty diesel lubricants, the corrosion inhibitor employed also served as an oxidation inhibitor, thus reducing lubricant deterioration through oxidation. This dual action will become reasonable when the mechanism of inhibitor action is discussed later.

Detergent Additives

Most present-day detergent additives are oil-soluble organic metal-containing compounds. The metal is usually one of the alkaline earths, but

*Paper "Additive Treated Crankcase Lubricants—Past, Present, and Future" was presented at SAE Metropolitan Section, New York City, Oct. 21, 1948. Complete paper on which this article is based is available from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.



O_2(AIR) + OIL

R_1COOH + RO_2H (HYDROPEROXIDE)

$Pb + RO_2H \longrightarrow PbO + ROH$

$PbO + 2R_1COOH \longrightarrow Pb(R_1COO)_2 + H_2O$

CORROSION REACTION:

$$Pb + 2R_1COOH + RO_2H \longrightarrow Pb(R_1COO)_2 + ROH + H_2O$$

CORROSION INHIBITOR ACTIONS—

1. FORM AN IMPERVIOUS FILM ON BEARING
2. RETARD OIL OXIDATION
3. REDUCTION OF ACID FORMATION BY FURNISHING ALKALINITY
4. REDUCE PEROXIDES

Fig. 3—Mechanism of copper-lead bearing metal corrosion and action of inhibitors

may be some other metal, such as aluminum, zinc, lead, nickel, and cobalt, and the compound is usually derived from a phenol or a sulfonic or phosphoric acid. Ashless detergents have been under study for years and, under certain conditions in the laboratory, show definite promise for the future, but up to the present have not been commercialized.

It is generally believed that piston and ring deposits are built up through the condensation of oxyacids produced by the partial oxidation of lubricant and fuel hydrocarbons. Such condensed oxyacids are resinous and appear to be a major constituent in piston varnish and the binder in ring deposits.

Detergents may act by forming the metallic salts of the oxyacids before they can condense or polymerize to varnish, as shown below:

$Al(Naph)_2OH + H(OA) \rightarrow Al(Naph)(OA)OH + H(Naph)$

$Al(Naph)_2OH + 2H(OA) \rightarrow Al(OA)_2OH + 2H(Naph)$

H(OA) = Oxyacids
Naph = Naphthenic acid radical

This is probably the type of chemical action in which the metallic soaps and phenates take part. However, the main mode of action of detergent additives is through a physical process. As a typical example, the action of a calcium sulfonate is due to its strong adsorption upon small particles of piston and ring deposit components, and upon the metallic surface of pistons and rings. Through this adsorption of detergent onto the minute particles of oxyacids, condensed oxyacids, asphaltenes, carbon, and the like, the growth of the particles into larger masses is prevented and the buildup of piston varnish or ring deposits is greatly reduced (Fig. 2). The aluminum naphthenate type of detergent also possesses adsorption detergency in a large degree.

Bearing Corrosion Inhibitors

As mentioned earlier, bearing corrosion inhibitors must be added to lubricants, particularly when alloy bearing metals more susceptible to corrosion than babbitt are employed. In recent studies on the corrosion of copper-lead bearings, it has been shown that the corrosion of the lead phase from these bearings is due to the combined action of an organic acid and an oxidizing agent. Corrosive organic acids may be formed by the oxidation of crankcase oils, or generated from a metal soap type of detergent. Generation of corrosive acids from certain metallic soap detergents was one of the principal reasons for switching over to present-day detergents that do not yield corrosive products in use.

Oxidizing agents present in a lubricant during use include dissolved oxygen from the atmosphere and organic peroxides formed by partial oxidation of the lubricant or fuel. There has been discussion of

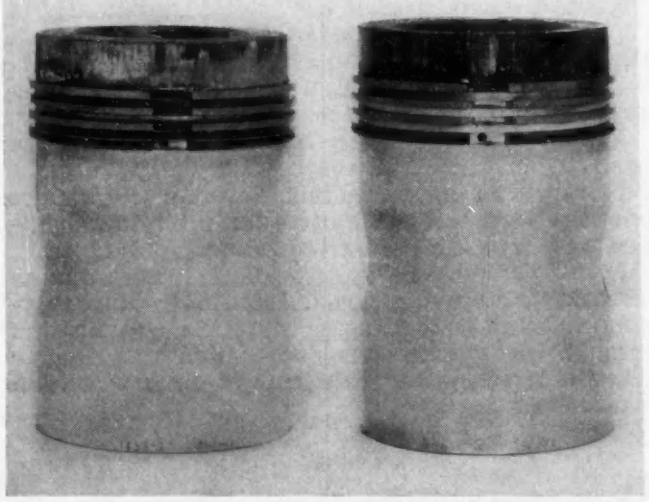


Fig. 4—Modified (240 hr, no oil change) L-1 Caterpillar test using high-sulfur fuel (left) and low-sulfur fuel (right) with same 2-104B lubricant



Fig. 5—Piston from supercharged Caterpillar 1-D test, using high-sulfur fuel and series 2 lubricant

the formation of oxides of nitrogen during combustion in internal-combustion engine operation and the subsequent formation of organic nitrogen compounds by reaction of these nitrogen oxides with the lubricant, but conclusive experimental proof for such action is lacking at this time. However, it is well known that organic nitrogen compounds, such as nitrohydrocarbons, are strong oxidizing agents which, in the presence of organic acids, would rapidly corrode lead in oil solution.

Since it has been established that both an acid and an oxidizing agent must be present for corrosion of copper-lead bearings to take place, there are several possible ways in which a corrosion inhibitor might act effectively.

In Fig. 3, a cross-section of a copper-lead bearing is shown, together with the mechanism by which corrosion of the lead phase occurs.

Step I—Oxidation of the lubricant by air, to yield organic acids and organic peroxides.

Step II—Contact of the peroxide (or oxygen) with the lead surfaces and reaction to form lead oxide.

$$\underset{\text{(Peroxide)}}{RO_2H} + Pb \rightarrow PbO + \underset{\text{(Alcohol)}}{ROH}$$

Step III—Reaction of lead oxide with the organic acid to form an oil-soluble lead soap which is dissolved into the body of the oil, exposing clean lead surface for the continuance of the corrosive action.

With this mechanism for corrosion we can then postulate the various ways in which an inhibitor might act.

1. If an impervious corrosion-resistant film could be formed on the surface of the bearing metal, the contact of the oxidizing and acid agents with the bearing surface could be prevented and corrosion would, therefore, be impossible. Such a film, however, would have to be very thin and be capable of being constantly repaired if it were ruptured occasionally. It is well known that several of the present-day corrosion inhibitors form surface films on bearings, which are easily visible.

2. If the inhibitor could prevent oxidation of the lubricant so acids or peroxides would not be formed, such action would be an effective bar to corrosion. However, to date our known inhibitors will not completely inhibit oil oxidation under engine conditions and, therefore, this antioxidant action is at best but a partial solution to the bearing corrosion problem.

3. By keeping the oil alkaline at all times, the acid concentration would be practically eliminated, and corrosion should be stopped. This method can hardly be a complete solution to the corrosion problem, since even when very high concentrations of alkaline additives are present in the original oil, this alkalinity disappears after a fairly short time of engine operation.

4. By the use of a reducing agent in the lubricant, which rapidly destroys peroxides or oxygen in solution in the oil, one could provide effective retardation of bearing corrosion.

In a recently reported series of experiments, five of the most widely used types of corrosion inhibitors were tested to determine the mechanism by which each retarded bearing corrosion. Table 2 gives the general results obtained.

It can be seen that most of the commercial inhibitors are fairly good oil oxidation inhibitors. Types C and D show an impervious film formation which should yield a high inhibiting efficiency. However, in actual engine tests D is not very effective compared to the other inhibitors listed. Type C is by far the most effective inhibitor listed.

Table 2—Mechanism of Inhibitor Action

Commercial Inhibitor Type	Formation of Impervious Film	Reduction of Oxidation of Oil	Reduction of Peroxides in Oil
A. Alkaline earth metal phenate sulfide	Fair	Excellent	Good
B. Metal organo-dithiophosphate	Fair	Excellent	Good
C. Phosphorus-sulfur organic type	Excellent	Excellent	Fair +
D. Organic phosphite	Excellent	Fair	Poor
E. Alkaline earth metal phenate	Fair	Fair	Fair

One possible reason for the poor showing of D in engine tests is the very crystalline and brittle nature of the film formed which, on a thin-walled bearing, could easily be broken loose by flexing of the bearing. In the laboratory tests, which showed an impervious film formed by inhibitor D, a solid rod of bearing metal was used. Inhibitor C forms a very flexible film on the bearing surface, which is also practically impervious.

All of the inhibitors studied, with the exception of the organic phosphite, were also fairly effective in reducing peroxides in the lubricant.

Heavy-Duty Oils

Diesel lubricants possessing both detergent and corrosion inhibitor action were well established before World War II, and during that war these 2-104B oils in diesel- and gasoline-engine service made a splendid record. Following the war, peacetime usage has largely settled down to that of heavy-duty oils for diesel engines and in gasoline engines used for heavy-duty bus and truck service.

For most gasoline engine use, either the so-called premium grade of oil, containing corrosion and oxidation inhibitors with slight detergent action, if any, or untreated lubricants are employed.

Oils for High-Sulfur Fuels

In the diesel field, the recent tremendous demand for fuels has made it necessary to market in several areas, fuels containing up to 1% sulfur and even higher. With such high-sulfur fuels, the usual 2-104B heavy-duty type of diesel lubricant is inadequate. To meet these new demands made upon the heavy-duty lubricant, the so-called series 2 oils have been developed. These new lubricants contain concentrations of carefully selected additives, which are several times the concentrations employed in the 2-104B oils, and have been successfully field tested by Caterpillar Tractor Co. and others.

One of the main difficulties caused by high-sulfur fuels is excessive ring deposits, which is eliminated by the use of these newer oils. It is generally believed that the oxidation products of the sulfur in the fuel contribute largely to the formation of these deposits. Series 2 oils now on the market all contain large amounts of metal compounds capable of off-

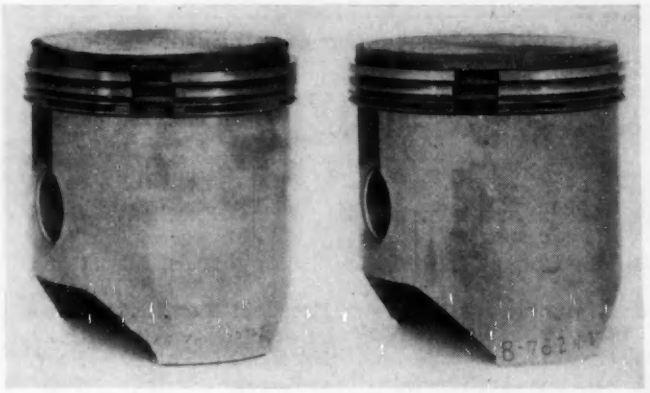


Fig. 6—Laboratory test results on series 2 oil; left: L-4 test, right: FL-2 test

setting the effects of sulfur dioxide or sulfuric acid.

Let us assume that during the life of a diesel engine it consumes, say, 25,000 gal of fuel, that this fuel contains 1% sulfur, and that in combustion the sulfur is all converted to sulfur dioxide. During the burning of this 25,000 gal of fuel there would be produced somewhat less than 2 tons of sulfur dioxide. If even a small portion of such oxidation products from sulfur gets behind the rings, on the piston walls, or into the crankcase, serious difficulties might occur, particularly under condtions where condensation of moisture took place.

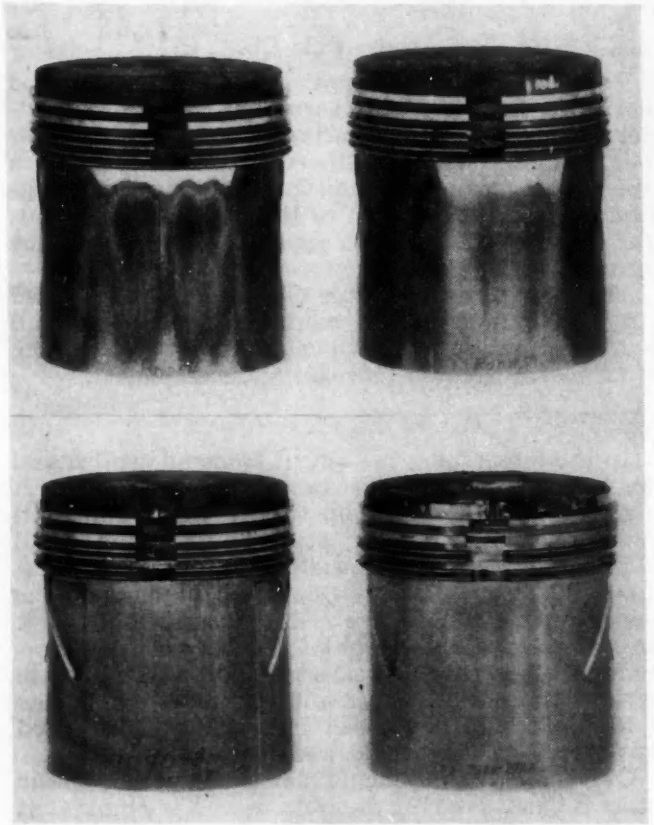


Fig. 7—Pistons from field test I; upper left: base oil, upper right: premium oil, lower left: 2-104B oil, lower right: series 2 oil
Conditions: 6000 miles without oil change, four 1½-ton Dodge trucks, 237 cu in. engine, 260 miles per day, 76-octane regular-grade house-brand gasoline, ½ ml tetraethyl lead

In Fig. 4 is shown a piston from the modified L-1 Caterpillar test, using low-sulfur (0.15% S) fuel and a good 2-104B lubricant, and also a piston showing excessive ring deposits with high-sulfur fuel (1% S) which was substituted in the same test and with the identical 2-104B lubricant.

In Fig. 5 is shown a representative piston from the 1-D supercharged Caterpillar test using high-sulfur fuel (1% S) and a series 2 diesel lubricant. It can be seen that ring and piston deposits have been reduced to negligible amounts.

Gasoline-Engine Crankcase Oils

The so-called premium-grade oils have been largely tested for effectiveness in the laboratory by the standard L-4 Chevrolet test, which involves continuous high-speed and high-temperature operation (Table 3). In field tests, particularly where temperatures are lower, and with discontinuous operation, frequently only fair improvements are noted when a premium-grade oil is compared with the untreated base oil (Table 4). Even heavy-duty additive treatment gives less improvement on gasoline-engine deposits in the field than one would expect from the results obtained on the L-4 test.

The effect of gasoline quality upon the L-4 test is clearly shown in Table 5. The exact causes of the different performances of gasolines in the L-4 test are not clearly understood at present, but that difference is appreciable. Additive concentrations are usually adjusted to give a good L-4 test with a reference gasoline of average cleanliness and average corrosiveness.

An examination of many additive-treated gasoline-engine lubricants shows that additive concentrations have been kept too low to cope completely with all conditions and fuels encountered in the field. One view of this situation is that additive concentrations have been kept low for gasoline-engine passenger-car service largely to meet an established (L-4) engine test conducted with a carefully selected fuel, results of which do not exactly correlate with those obtained in certain types of field service. During the war the shortage of additives made the use of minimum concentrations of additives imperative, but in peacetime adequate additive concentrations should be employed to meet service needs, provided such cencentrations are economically justified and provided no detrimental actions occur, such

Table 3—Summary of Test Results
CRC L-4 Procedure

	Base Oil	Premium Oil	2-104B Oil
Engine Condition:			
Piston Varnish Rating	2.5	8.0	8.5
Varnish Rating-Total	11.5	40.5	43.0
Sludge Rating-Total	23.0	40.0	42.5
Combined Rating	34.5	80.5	85.5
Bearing Weight Loss:			
G per bearing (average)	0.745	0.167	0.092
Drain Analysis:			
Conradson Carbon, %	3.7	2.7	2.36
Viscosity Increase, %	182.0	60.5	53.5
Neutralization No.	3.75	1.3	0.89

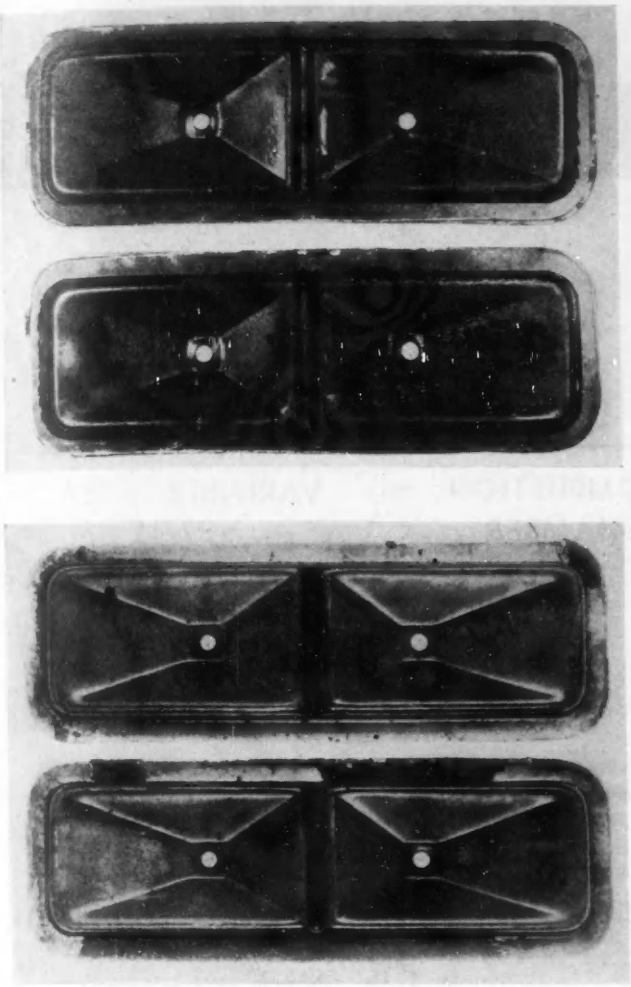


Fig. 8—Sideplates from field test 1; upper: premium oil, lower: series 2 oil

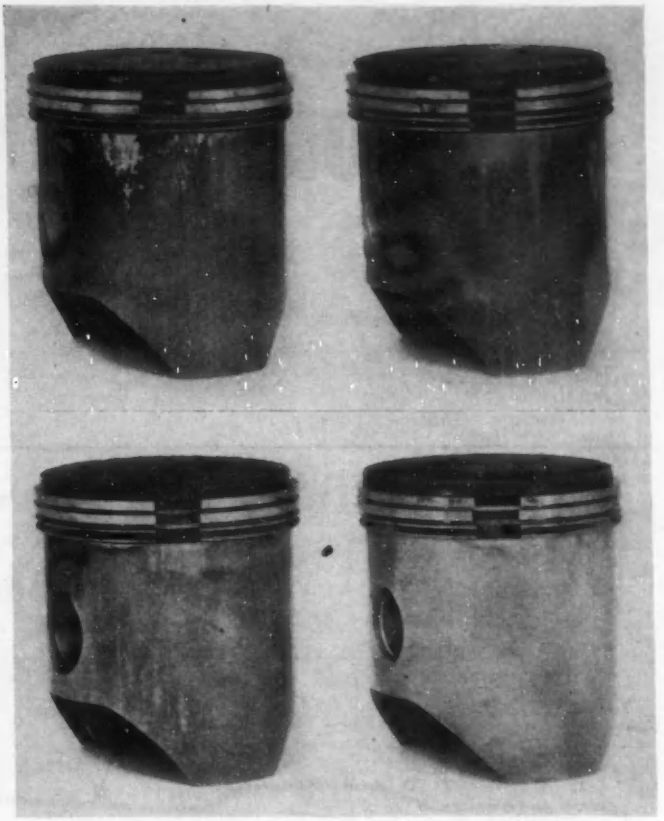


Fig. 9—Pistons from field test II; upper left: base oil, upper right: premium oil, lower left: 2-104B oil, lower right: series 2 oil
Conditions: 6000 miles without oil change, 1½-ton Chevrolet trucks, 216 cu in. engine, 140 miles per day average, 76-octane regular-grade house-brand gasoline, 2 ml tetraethyl lead

as an increase in ring and cylinder wear, or in valve burning or sticking.

The excellent results obtained in diesel engines with the series 2, high additive concentration lubricants led to the following exploratory investigation of their use in gasoline engines. Much work remains to be done before such products can be proposed for use in gasoline engines under all conditions, but the results are very interesting.

Fig. 6 shows L-4 and low-temperature Chevrolet FL-2 test results on a series 2, high additive content oil, and Figs. 7, 8, and 9 show pistons and sideplates from field tests conducted on two separate fleets of gasoline-engine trucks, where excellent controls on operation and fuels were maintained, and involving combinations of high- and low-temperature operation. Test pistons are also shown when the untreated base oil was used.

It is felt that additive concentrations adequate to meet all operating conditions in a gasoline engine would be considerably lower than the series 2 diesel oils tested, and it may be necessary to modify the additive types used to improve performance further. When these factors have been determined, economic considerations must be thoroughly studied to ascertain if the use of such oils can be justified by lower vehicle operating costs.

Table 4—Summary of Field Test Results[a]

	Base Oil	Premiun Oil	2-104B Oil
Engine Condition:			
Piston Varnish Rating	3.5	5.0	8.0
Varnish Rating-Total	41.0	42.0	43.5
Sludge Rating-Total	35.5	36.0	41.5
Combined Rating	76.5	78.0	85.0

[a]Based on CRC L-4 rating scale.

Table 5—CRC L-4 Test Results
2-104B Oil

Gasoline	**A**	**A**	**B**
TEL Content	**None**	**2.7ml**	**2.7ml**
Engine Condition:			
Piston Varnish Rating	10.0	9.5	8.0
Varnish Rating-Total	50.0	49.0	40.0
Sludge Rating-Total	42.5	42.0	41.0
Combined Rating	92.5	91.0	81.0
Bearing Weight Loss:			
G per bearing (average)	0.157	0.539	0.320
Drain Analysis:			
Conradson Carbon, %	1.8	3.0	2.84
Viscosity Increase, %	19.0	62.0	47.0
Neutralization No.	0.9	2.0	1.0

Afterburning Mitigates High

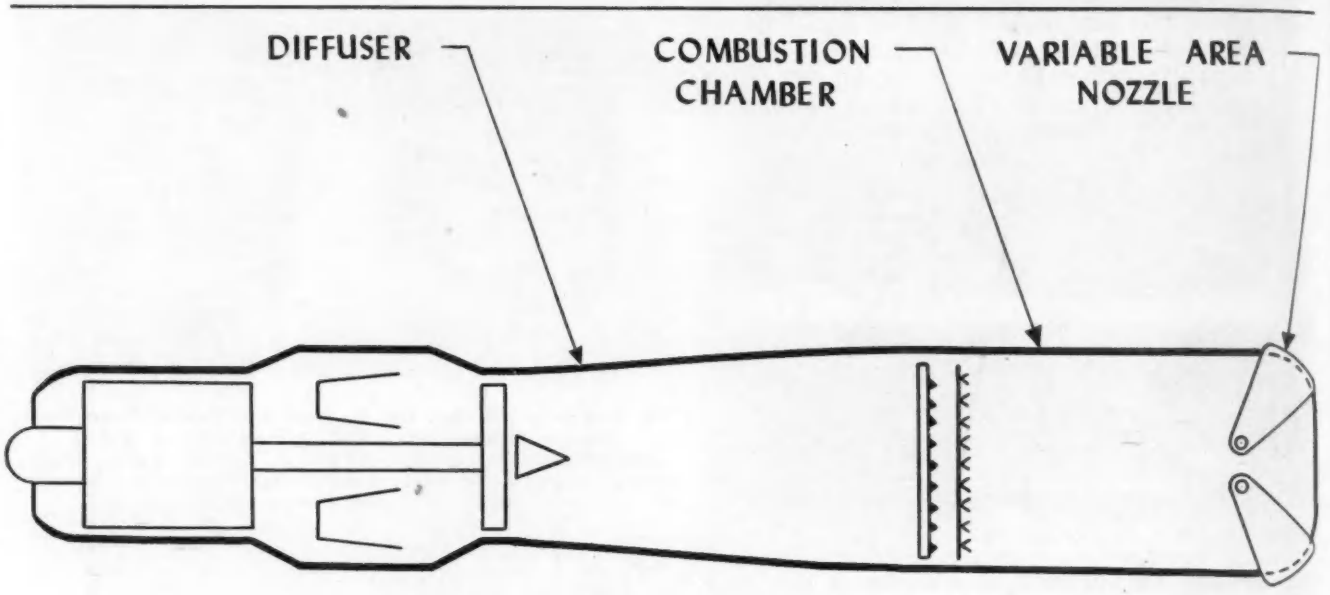


Fig. 1—Diagram of turbojet with afterburner

ALTHOUGH afterburning in turbojet tail pipes boosts fuel consumption markedly, afterburners may be the answer to one of the problems associated with the turbojet's high fuel consumption—how to take-off with the heavy fuel load.

The turbojet's fuel consumption at its cruising condition is much greater than the reciprocating engine's consumption at its cruising condition. Hourly fuel consumption of the turbojet decreases markedly with increase in flight altitude. This means that turbojet aircraft will carry a large fuel load and fly at high altitude. Turbojet aircraft must be designed to accommodate the large fuel load and to withstand the high ambient-to-cabin pressure differential at high altitude. Both factors increase gross weight.

This tremendous weight, plus the turbojet's sensitivity to temperature and pressure, may call for thrust augmentation at take-off. That's where afterburning comes in.

To keep fuel consumption within reasonable limits, turbojet aircraft will have to fly in the 30,000-40,000-ft range as much as possible. At 20,000 ft, fuel consumption at 500 mph is about 40% less than at sea level. But it is worth while to go up another 10,000 or 20,000 ft where fuel consumption decreases about 60 and 70% respectively from sea level values. Even at 35,000 ft, a turbojet transport corresponding to the DC-6 would cover only about 0.065 miles per lb fuel. (The DC-6 travels about 0.14 miles per lb at 20,000 ft.) The turbojet airplane must carry decidedly greater fuel loads for a given range.

The high fuel consumption rates add to the airplane's gross weight. Not only is there the weight of the fuel consumed over the route flown plus adequate reserve for continued consumption for a reasonable period of time, but also there is the weight of the containers for all this volume of fuel.

(Of course, improved navigation and landing aids will cut the amount of reserve fuel needed by keeping planes on the route and eliminating airport holding. And decreases in turbojet fuel consumption that undoubtedly can and will come, will cut both route and reserve fuel supplies.)

For flight at 30,000-40,000-ft altitudes, the structure may have to be heavier per unit volume to with-

SFC Problem with Turbojets

BASED ON PAPERS* BY **Dimitrius Gerdan**
Chief Engine Engineer, Allison Division, GMC
and D. J. Jordan
Staff Engineer-Powerplants, Chance-Vought Aircraft Division, UAC

stand the pressures. Maximum differential pressures will be about 50% greater than those used now for design of transports for 15,000-22,000-ft service.

These facts lead to the conclusion that, if a turbojet transport for domestic operations is to carry a reasonable payload, the airplane will be in the 80,000-120,000-lb gross weight class, at least.

Afterburning Aids Take-Off

Operational characteristics of the turbojet complicate the problem of raising a heavy airplane off the runway. Take-off thrust varies inversely with altitude and temperature. At an airfield altitude of 10,000 ft, take-off thrust is only about 84% of the sea level value, assuming standard temperatures at both altitudes. Similarly, sea-level take-off thrust at 110 F is only 84% of that obtained at 59 F. The combined effects of an airport at 5000-ft altitude and a temperature of 90 F would reduce take-off thrust by about 22% from that attainable at sea-level standard conditions.

One way to provide sufficient thrust at take-off despite high take-off weight and engine sensitivity to climate is to add an afterburner to the turbojet. Afterburning is the addition of heat to the working fluid by burning fuel in the unburned oxygen in gases discharging from the turbine.

Major components of an afterburner are the diffuser, the combustion chamber, and the variable-area exhaust nozzle. The diffuser slows gases to a velocity suitable for combustion. The variable-area nozzle allows area to be increased when the afterburner is operating so that back pressure on the turbine remains the same.

Afterburning does not affect basic engine performance; it increases exhaust-gas velocity and, therefore, thrust.

Afterburner performance can be estimated from simple calculations if certain secondary corrections are neglected. For a typical turbojet without afterburning, exhaust gas total temperature is about 1700 F and velocity about 1820 fps. If exhaust gas temperature is raised by afterburning and nozzle area is increased so that pressure ratio across the nozzle is unchanged, gas velocity will vary as the square root of the absolute temperature; and, at zero airplane velocity, so will thrust.

Thus, if the gas is raised from 1700 to 3000 R by afterburning, jet velocity will increase

$$1820\sqrt{\frac{3000}{1720}} = 2420 \text{ fps or } 33\%$$

Engine take-off thrust also increases 33%.

Only limitations on obtainable thrust are the temperatures allowable in the afterburner structure and the amount of excess oxygen available for combustion in the afterburner.

While gas velocity increases as the square root of the temperature ratio, specific volume increases as the ratio itself. Since the nozzle area required to pass a given mass flow varies directly as the gas volume (that is, directly with the temperature ratio) and inversely as the gas velocity (that is, inversely as the square root of the temperature ratio), area will vary as the square root of the temperature ratio. For the example, area should be increased 33%.

Afterburning increases thrust on the engine by reducing the tension in the engine tail pipe. Since the pressure downstream of the turbine is the same with and without afterburning, the forces on the engine components are unchanged. But without

* Paper "Problems in Application of Turbojet Engines to Air Transport," by Gerdan and paper "The Next Step—Afterburning," by Jordan were presented at the SAE National Aeronautic Meeting, Los Angeles, Oct. 7, 1948. Complete papers on which this article is based are available from SAE Special Publications Department. Price: 25¢ each paper to members, 50¢ each paper to nonmembers.

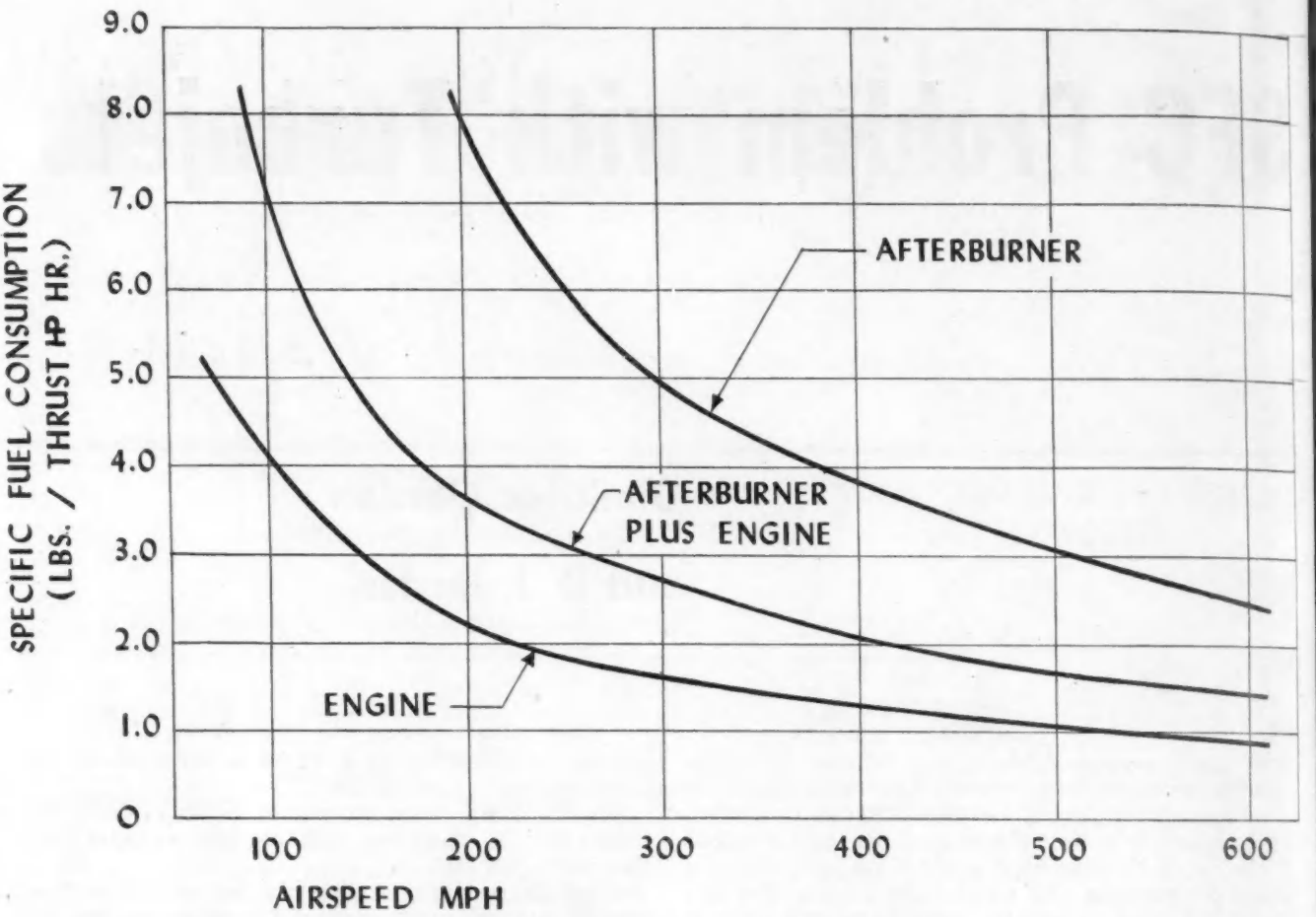


Fig. 2—Specific fuel consumption of turbojet and afterburner

afterburning there is a high pressure force acting on the converging walls of the exhaust nozzle in the aft direction. This force is carried in tension through the tail pipe to the engine structure. With the afterburner operating, nozzle area is increased and the pressure force on the converging walls of the exhaust nozzle is decreased. Therefore, tension in the tail pipe is decreased.

Afterburning Entails High SFC

Well-known disadvantage of the afterburner is its enormous specific fuel consumption. At static conditions, the afterburner mentioned in the example would burn more than four times as much fuel per pound thrust as the basic engine. Two factors combine to make consumption high: The thermal efficiency of the afterburner is lower than that of the basic engine because heat is added after the turbine where pressure is lower. And propulsive efficiency is lower because jet velocity is higher. (Propulsive efficiency is a function of the difference between jet velocity and airplane velocity.)

Afterburning is attractive for increasing maximum thrust despite its fuel consumption because it affords higher thrust per unit frontal area and per unit airflow.

And operation of the afterburner need not be limited to take-off. It can boost maximum thrust in flight, too. In fact, the simple turbojet is probably thrust-limited to some particular supersonic speed, above which, afterburners must be used.

Afterburning net thrust and specific fuel consumption improve with air speed. As the velocity of the engine in the air increases, airflow through the engine increases and so does the pressure ratio across the exhaust nozzle due to the ram pressure increase. This results in large increases in both intake drag and nozzle thrust. Fortunately, nozzle thrust increases faster, so that the net thrust due to afterburning increases markedly. Specific fuel consumption drops because the cycle is more efficient at higher nozzle pressure ratios. Propulsive efficiency improves also because jet velocity increases at a lower rate than airplane speed.

Another means of thrust augmentation that has been used successfully for take-off is water-alcohol injection into the compressor inlet. This increases the mass flow through the engine by increasing density. With water-alcohol injection, the unaugmented thrust rating at 59 F can be maintained to ambient air temperature conditions slightly over 110 F. A mixture of two parts water and one part AN-A-18 alcohol is used at the rate of about 30 gal per min—a very high rate of liquid consumption. Engine and aircraft components for a typical installation would have a dry weight of approximately 60 lb.

5 Ways that Diesels Wear

- **Mechanical Action**
- **Scuffing or Welding**
- **Surface Disintegration**
- **Abrasive Action**
- **Corrosive Action**

EXCERPTS FROM PAPER* BY

John W. Pennington

Staff Engineer, Research Department
Caterpillar Tractor Co.

INVESTIGATORS of diesel engine wear find five processes by which metal is removed from piston ring and cylinder surfaces: (1) direct mechanical action, (2) scuffing, (3) surface disintegration, (4) abrasion by foreign particles, and (5) corrosion. Proper diagnosis of wear mechanisms is important in remedying abnormal wear.

Wear by Mechanical Action

In any case where the piston ring is moving over the cylinder surface, the surfaces actually will be in close contact at relatively few points due to irregularities of the surfaces. It is easy to picture that irregularities on one surface will cut off or deform irregularities on the other. This is one of the things that happens when an engine is broken in. Under proper conditions, it will lead to a smoothing of the surfaces, an increase in the area of actual contact, and an improvement in the load-carrying ability of the surfaces.

Rapid wear usually is associated with the break-in period and such wear is desirable in that some wear must take place before the parts can fit properly. Effects of this process show up first where pressure and temperature are high and the rubbing velocity is relatively low—in the top end of the cylinder. Under clean running conditions machining marks may be removed readily from the top portion of the cylinder and remain in the lower part almost indefinitely. Whether or not this form of wear will continue at an appreciable rate after the break-in depends on several factors:

1. Surface Condition—If both surfaces reach a form such that the interlocking of high spots is reduced to a minimum, wear by this process may virtually cease. If either surface has irregularities which penetrate the oil film, wear can be expected to continue.

2. Material Properties—Hardness and the relative hardness of the two parts is a factor. Hardness determines how far points on one surface will penetrate the other surface and which part will cut the other. The presence of hard, sharp constituents in either part will be a factor, both in the cutting of one part by the other and in the fact that such particles, if torn loose from the surface, can cut both parts.

3. Lubricant—Lubricant viscosity has an effect since it helps to determine how close the two surfaces will approach each other. We frequently have observed that original finish marks are removed much sooner when a light break-in oil is used than when a heavy oil is used. We have no direct evidence of the effect of other lubricant properties on this process. If there is any part of the surface which is not covered by an oil film, wear will be accelerated by this and other processes.

Scuffing Roughens Surface

The second process which may take place is the phenomenon commonly called scuffing. Scuffing is usually pictured as the welding of points on the two surfaces and a subsequent tearing away of the welded junctions. This manifests itself in a roughened condition of the cylinder surface and a high wear rate of the rings and pistons. Once the surface has been roughened by scuffing, a considerable amount of wear by mechanical action would be expected to occur.

In our experience, the scuffing in the cylinder is usually most prominent in the center portion of the ring travel area and does not necessarily show up as wear of the cylinder itself. The damaged cylinder surface can be reconditioned by honing a small amount of material from the bore.

Scuffing, if severe, will lead to very early failure of the engine. Under some conditions we may find scuffing and subsequent healing so that it causes an abnormally high wear rate of the rings rather than immediate failure. In these cases we usually find an increase in cylinder wear also. This probably is caused by particles torn from both surfaces.

Several factors affect the scuffing problem:

a. Surface Condition—Scuffing is a particularly critical problem during the break-in period. During

* Paper "Piston Ring and Cylinder Wear in Diesel Engines," was presented at SAE National Tractor and Diesel Engine Meeting, Milwaukee, Sept. 8, 1948. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.

this period there is considerable intimate contact of high points and, therefore, opportunity for scuffing to occur. For welding to occur, a high surface temperature must be reached and there must be clean metallic contact. Any contaminating film will aid in preventing scuffing.

Chemical coatings of various types have been used very effectively in preventing break-in scuffing. Various types of interrupted surfaces also have been successfully used to prevent scuffing. Surface roughness is not in itself the all-important factor; the type of surface profile is important as well as the condition of the surface metal. One point which should be remembered is that the materials must be able to run together after any special coatings or finishes are worn off.

b. Material Properties—Just exactly which properties make a material resistant to scuffing have not been explained. By experience we know that certain materials—such as cast iron—are good in this respect while others, such as steel, are inclined to give trouble. A common rule has been not to use the same material for both parts. Cast-iron rings, however, are used very successfully in cast-iron cylinders. We would expect the melting point and the coefficient of friction to be important factors. Thermal conductivity also may be important.

c. Lubricant—The viscosity of the lubricant has an effect on scuffing. Heavy oils provide a film which is more difficult to penetrate. Volatility may have an appreciable effect in that it determines how well the oil resists being burned from the surface. E-P compounds, such as sulfur, which prevent welding can increase the scuffing resistance of an oil appreciably.

The elusive property of the oil we commonly call "film strength" is frequently mentioned in connection with scuffing. In fact, it is sometimes defined as the ability to resist scuffing. Just exactly what physical or chemical properties enter into what we call "film strength" is hard to determine. The properties mentioned together with adhesive properties are probably the important factors.

If any parts of the surface are not adequately lubricated, they will be very susceptible to scuffing.

Temperature, pressure, and rubbing velocity are important factors. The possibility of scuffing is increased as these conditions are made more severe. Any factors such as distortion, which cause localized high pressures, will tend to produce scuffing. Dust can aggravate scuffing by cutting through protective films and exposing clean metal.

Scuffing is much less of a problem with narrow compression rings than with wide compression rings.

A possible explanation for this is that as the ring width is increased, the number of close contacts per stroke between high points on the ring face and a high point on the cylinder surface also is increased. This means that the temperature of the point on the cylinder surface will be increased, the lubricant may be more effectively removed, and welding will be more likely to occur.

Surface Disintegration

A third type of failure which can occur is called "surface disintegration". Just what process is the basic cause of surface disintegration is not too clear. Apparently stresses sufficient to cause removal of the metal from the surface can occur without rupturing of the oil film. This would indicate that something like surface fatigue is largely responsible. Very high stresses can be carried through the oil film and the passing of the rings over the cylinder surface would certainly cause repeated surface stresses.

It is probable that we have called many cases of this kind "scuffing" and have blamed factors which could not be expected to influence the actual process. Only by a careful study of the surfaces and a determination of the actual mechanism of removal involved will we gain enough knowledge of this problem to discuss it intelligently. We would expect the properties of the material and the surface finish and stress condition of the surface metal to be important factors. Lubricating oil may not be much of a factor—viscosity is the property most likely to influence this process.

Action by Abrasive Materials

One well-recognized problem is wear caused by abrasive entering from either the top or the bottom of the cylinder. The usual case is abrasive material entering with the intake air. We do find cases, however, in which the abrasive has entered the crankcase and is brought into the cylinder from the bottom with the lubricating oil.

The best protection against this type of wear is, of course, good air filters and oil filters. But even with the best of such equipment available today, difficulty is encountered in certain areas and under certain types of operation. An additional factor to consider is that while the best filters may be provided, we can not insure the proper maintenance of such filters.

Abrasive wear is essentially the same problem as the wear by mechanical action. The additional factors which influence the wear rate are the quantity, size, shape, and mechanical properties of the abrasive materials which enter. We would expect the properties of the ring and cylinder material which influence the wear by mechanical action to influence abrasive wear in about the same manner. Considerable difference may be found, however, in that the abrasive material which enters is usually very hard compared to either ring or cylinder material and such factors as embeddability may have a considerable influence.

In the wear by mechanical action we expect, and usually find, that the harder material cuts the softer material. When abrasive is brought into the engine we sometimes find that the abrasive embeds in the softer material and actually increases the wear rate of the harder material more than that of the softer material.

Fig. 1 shows some wear profiles of cylinders which have been run under various conditions. The profiles are similar except for the case where abrasive enters with the lubricating oil. In this case, a definite wear step is obtained at the bottom of ring travel and the wear step at the top is not nearly as great as in the case of abrasives entering from the top of the cylinder. The other two profiles showing wear with high sulfur fuel will be discussed later.

Another difference which is found is that when abrasive material enters from the top of the cylinder, we can obtain very high wear of the piston rings

Propose Methods To Combat Wear

Approaches to reduction of wear by the processes described by Pennington are offered by discussers of his paper. Emphasis is given to chrome plating, neutralization of sulfur in fuels, and improved surface finishing.

T. C. Jarrett and R. D. Guerke, Piston Ring Division, Koppers Co., Inc., report that field experience points up the merits of plating piston rings with porous chromium. They find it reduces cylinder wear about 75% and increases piston ring life three to five times over that normally expected with cast-iron rings.

Chrome plating the compression ring seems to offer the best possibility "for eating our cake and having it too," agrees A. M. Brenneke, Perfect Circle Corp. He feels that we must not leap to wider compression rings as the answer to wear. Maximum width must be dictated by the individual engine design's susceptibility to scuffing.

Ideal though impractical way of reducing corrosion due to sulfuric acid is to remove sulfur from the fuel, notes A. G. Cattaneo, Shell Development Co. But this added refining step rarely can be justified economically. Other methods must be used, he says, particularly since future outlook is for an increase in concentration of sulfur compounds in crude petroleum. At least three such methods are available today and they consist of assuring the presence of a chemically basic counter agent on combustion chamber walls.

For example, a basic calcium salt can be added to the lubricant. This can reduce by 70% the wear caused by a 1% sulfur fuel. Since the basic additive is consumed in reacting with the acid, fuels with high concentrations of sulfur require very large amounts of additive in the oil if effectiveness is to be maintained for a reasonable oil change period.

Second method of maintaining basicity suggested by Cattaneo consists of circulating the oil over a bed of lime pellets. This is most effective when combined with a basic additive in the oil.

A third method consists of adding the basic compound to the fuel. Advantage of this is that the fuel producer could match the amount of basicity with sulfur concentration. Thus additive depletion would not be a problem. Alkaline earth metal is very suitable for this purpose. If sodium is used, 0.03 weight equivalent of sodium to sulfur—calculated on the basis of sodium sulfate as an end product—is a practical concentration.

Actual finish of the surface and metallurgical and physical structure of the extreme uppermost layer may be entirely responsible for surface disintegration, largely responsible for abrasion and scuffing, and also

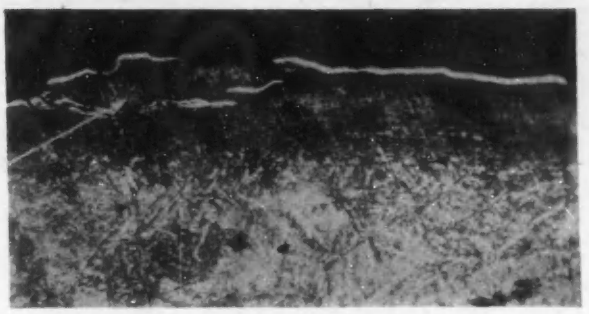


Fig. A—This photomicrograph of a smeared layer shows one particle ready to separate. Although the smeared layer here is only 0.002 in., it is enough to ruin the cylinder surface. Severe grinding could produce a layer even thicker than this one

a decisive factor in surface susceptibility to corrosion. This is the thesis of discussers W. F. Joachim and W. G. Payne, U. S. Naval Engineering Experiment Station.

They say that the smooth, bright cylinder wall finish after grinding is very likely to be a layer of smeared metal. It may extend several thousandths of an inch, caused by heat generated during grinding and by the tearing and mashing from force of the cutting edge. Fig. A shows a good example of such an area.

Here is how this condition aids wear: Movement of the compression ring builds up a hydraulic pressure with the oil pushed ahead of it. This hydraulic pressure forces itself under any loose, flaky, or partially bonded particles which eventually flake out, leaving a pit. Oil trapped in the pit by the ring lifts surrounding lightly-bonded particles, enlarging the hole.

This type of surface would be much less resistant to abrasion than would a dense, hard surface, observe Joachim and Payne. It also accelerates scuffing because the hard particles, when partly loosened, would likely project through the oil film to contact projections on the rings and piston. And the area exposed to corrosion is greater with a rough surface than with a smooth one.

The answer lies in preparing the cylinder bore properly to eliminate the layer of smeared metal. While this comes within the production department's domain, engineering should carry its share of the responsibility. A clean surface would permit use of a very smooth surface with only a desired scratch pattern. Engines could be designed to use greater conformance of piston and cylinder, controlled lubrication, and harder-surfaced cylinders.

The benefits derived would include: (1) wear resistance of a smooth surface, (2) elimination of surface breakdown, (3) increased efficiency of a thin oil film, and (4) control of oil consumption.

and cylinder liner without very much wear of other engine parts. When the abrasive material is carried in the lubricant, we find a very high wear rate of all rubbing parts which the lubricating oil reaches.

Fig. 2 shows the effect of the source of the abrasive on the relative wear rates of the various rings and the cylinder. In each case the wear of the top piston ring is taken as 100%. (All of the piston rings are cast iron.) When dust enters with the intake air the wear of the top piston ring is about three to five times as great as the second and third compression ring wear and 25 to 50% greater than the oil ring wear. When abrasive material enters from the bottom of the cylinder with the lubricant, we find the wear of all the compression rings to be about equal and the oil-ring wear is about four times as great as compression-ring wear.

When abrasive enters from the top, the top ring radial wear is about three times as great as the maximum radial wear of the cylinder. When abrasive enters from the bottom, the compression-ring radial wear is six or seven times as great as the maximum radial wear of the cylinder.

Fig. 3 shows the effect of a hard chromium-plated

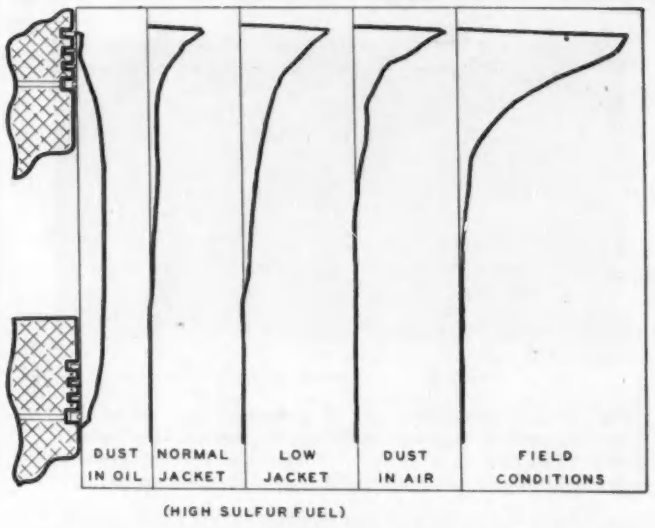


Fig. 1—Cylinder wear profiles. All are similar, with the exception of the case for abrasives introduced with the lubricating oil

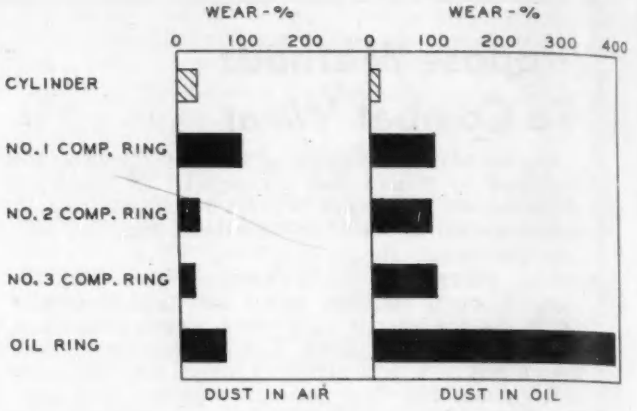


Fig. 2—Relative wear rates at various points as affected by introducing the abrasive in the air and in the oil. Top ring wear has been taken as 100% and the other values rated accordingly

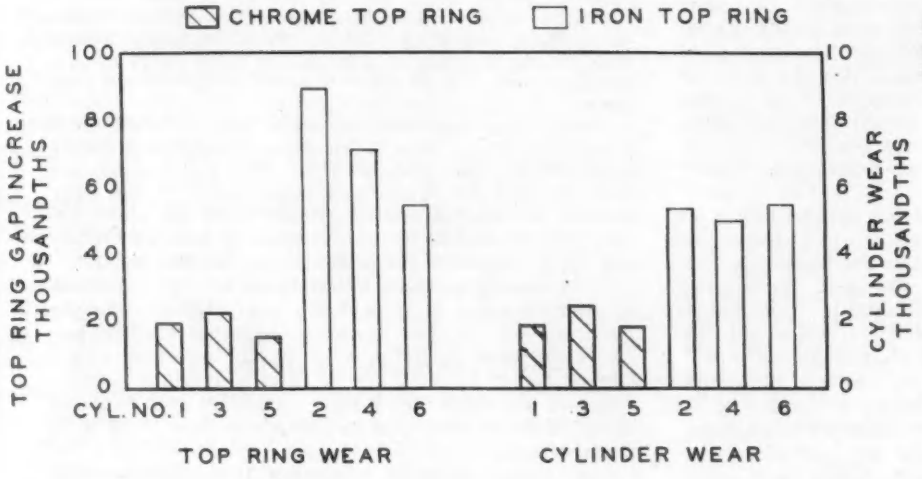


Fig. 3—Chromium-plated top compression ring reduced both top ring and cylinder wear in dust tests, as shown

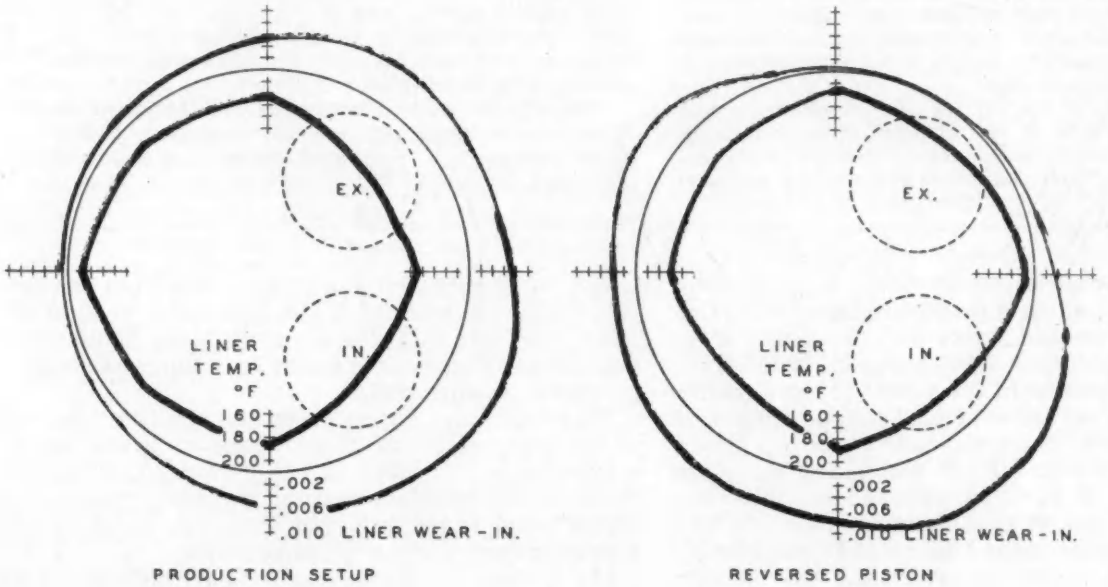


Fig. 4—These cylinder wear patterns indicate that high wear regions are in the low-temperature zones

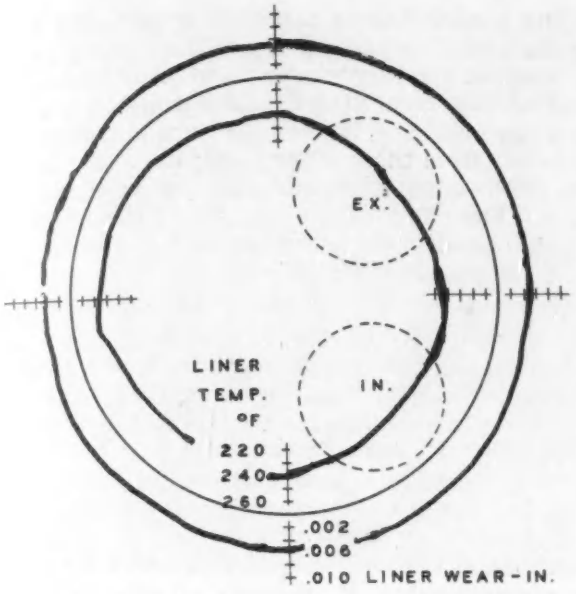


Fig. 5—With a high sulfur fuel, in the same engine as that for results in Fig. 4, this is the kind of wear pattern obtained at normal temperatures. It is more uniform than patterns at low temperatures

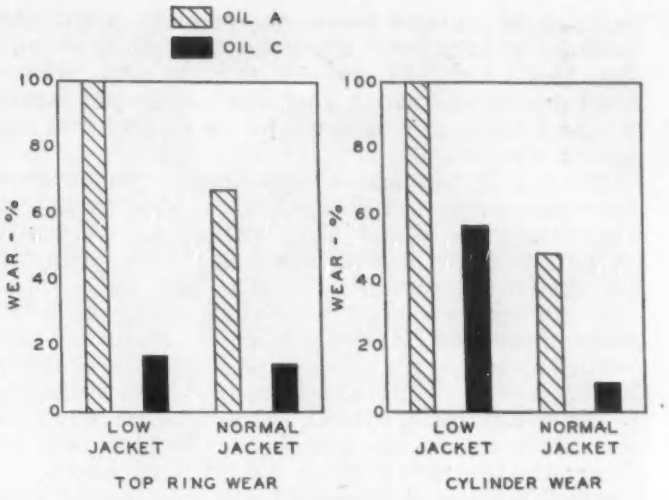


Fig. 6—How lubricating oil affects wear with a 1% sulfur fuel

top compression ring on piston ring and cylinder wear when abrasive material enters with the intake air. This test was run in a split 6-cyl engine—three cylinders had chromium-plated top compression rings while the other three had unplated cast-iron top compression rings. In running this test, dust was fed at a constant rate to the engine oil bath air cleaner. A very marked reduction in both top compression ring and cylinder wear is found when the chromium-plated ring is used. We have not found the chromium-plated top ring to affect wear rate of the lower rings.

A number of theories have been proposed to explain reduction in cylinder wear with the chromium-plated top ring, but no proven explanation is yet available. It may be due to a combination of factors such as ability of the chromium plate to resist embedding of hard particles and the low coefficient of friction of the chromium surface.

Corrosion Aided by Sulfur

Principal factors influencing corrosion—fifth wear process—in diesel engines seem to be in the fuel and low temperature operation. Sulfur can cause high wear rates under both high and low-temperature conditions; low-temperature operation accelerates wear—particularly cylinder wear—with and without sulfur present.

Fig. 4 gives some interesting cylinder wear patterns. In both of these cases a 1% sulfur fuel was used with the same lubricating oil. The jacket temperature was held at 100F. Cylinder temperature was measured at eight points around the cylinder with thermocouples opposite the top of top ring travel, and 1/16 in. from the inner wall. The diagram at left is typical of the wear pattern obtained with this engine operating under these conditions. Similar patterns have been obtained on a large number of tests.

It was known from previous work that if we reversed the piston in this engine, no effect on performance could be found until a high load was reached, but that the temperature distribution was radically changed. This is caused by the fact that the combustion space is located off center in the piston. The diagram at the right in Fig. 4 shows the temperature and wear pattern obtained when the piston is reversed. Both have been shifted and the high wear region is again in the low temperature region.

It should be remembered that the temperature at which condensation will occur is affected by such factors as relative humidity and pressure and also that the important temperature is the internal surface temperature of the cylinder. This temperature varies cyclically so that any measurement of jacket temperature or cylinder wall temperature is only a rough indicator of the actual surface temperature.

We would expect a sharp increase in corrosion at a point as soon as condensation occurs; but if the surface is cooled to a still lower temperature, the corrosion rate probably still will increase since condensation will take place more readily. Another point which these diagrams in Fig. 4 indicate is that very irregular wear patterns are sometimes found and that measurement of wear at only a few points can be very misleading in comparing wear rates.

Fig. 5 shows the wear pattern obtained on the same engine at a high jacket temperature with a high sulfur fuel, but with a different lubricating oil. Not all the wear patterns obtained at normal temperatures are this uniform, but they are more uniform than those obtained at low temperatures. As shown in Fig. 1, essentially the same vertical wear profile is obtained with high sulfur fuel at both high and low temperatures.

Figure 6 shows the effects of the lubricating oil on the wear obtained with a high sulfur fuel. Consider first the results obtained with oil A. When the jacket temperature is lowered from 175F to 100F the cylinder wear is doubled and the ring wear is increased about 50%. When oil C is used, the cylinder and piston ring wear at normal jacket is about one-fifth as great as with oil A. At low jacket temperature the ring wear remains at about the same

level as at normal jacket temperature while the cylinder wear is about five times as great as at normal jacket temperature. Oil C drastically reduces the cylinder and piston ring wear at normal jacket temperature and reduces the piston ring wear at low jacket temperature.

The actual amount of increase in cylinder wear between normal and low jacket temperature is just about the same with oil C as with oil A. We would explain this as follows: The wear of the cylinder and piston rings caused by high sulfur fuels when the cylinder wall temperatures are above the dewpoint is caused by the SO_3 (formed in burning the sulfur) attacking the lubricating oil and the cylinder surface at this point. Oil A does not have sufficient ability to neutralize the SO_3 so that the cylinder and ring surfaces can be attacked. Oil C is able to neutralize the SO_3. When the cylinder wall temperature is below the dewpoint, the condensed H_2SO_4 can attack the exposed cylinder surface since the surface is scraped almost clean of lubricating oil at the top end.

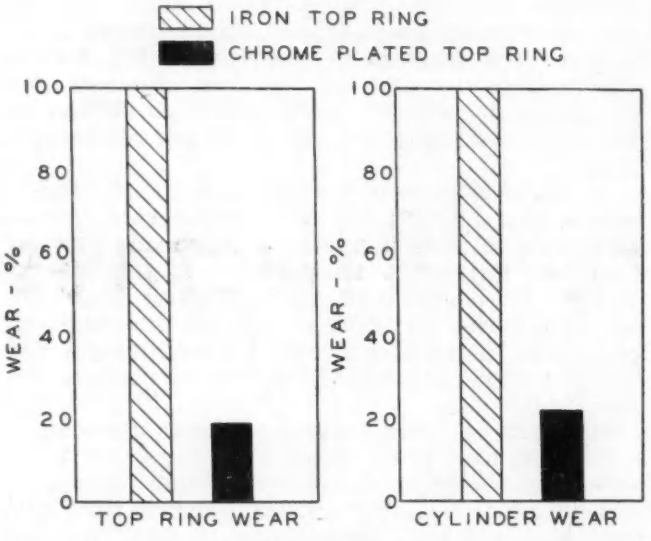


Fig. 7—Effect of chromium-plated top ring on low-temperature wear—with high-sulfur fuel

The piston ring is rather well protected by oil, so that oil C is able to neutralize the acid before it reaches the ring surface and thus protects the ring surface from attack. Corrosion can be caused by other acids and low temperature also accelerates the wear from these other acids; but sulfur is without much doubt the chief criminal in this type of wear. The effect of the basicity of the lubricating oil or its ability to neutralize acid has perhaps not been sufficiently realized.

Wear rates with an oil such as oil A can be reduced by shortening the oil change period.

Piston ring and cylinder material have a considerable effect on wear from corrosion. Fig. 7 shows the effect of a chromium-plated top compression ring. Both cylinder and ring wear are greatly reduced.

Effect of the lubricating oil would indicate that abrasive materials formed in the burning of the fuel are not responsible for the wear with high sulfur fuels. Abrasive materials may be formed by a combination of products of combustion and lubricating oil or lubricating oil additives. Only actual evidence we have seen of this is in a few isolated cases where a buildup of deposit on the top land of the piston has worn the cylinder above the ring travel area.

These are the principal processes by which we know wear can be caused. Many factors other than those listed influence these processes; and possibly (for example in the case of surface disintegration) we may be putting more than one process under a common heading due to lack of detailed knowledge. In our experience, however, these are the important factors and processes in practical cylinder and ring wear problems .

Figure 8 emphasizes the importance of knowing the exact process under which we are testing a material. The material which is definitely the better under corrosive conditions is just as definitely the poorer under abrasive conditions. By determining more accurately just what processes are taking place on the piston ring and cylinder surfaces, we will be able to use to greater advantage the help the chemists and metallurgists can give us in combating wear.

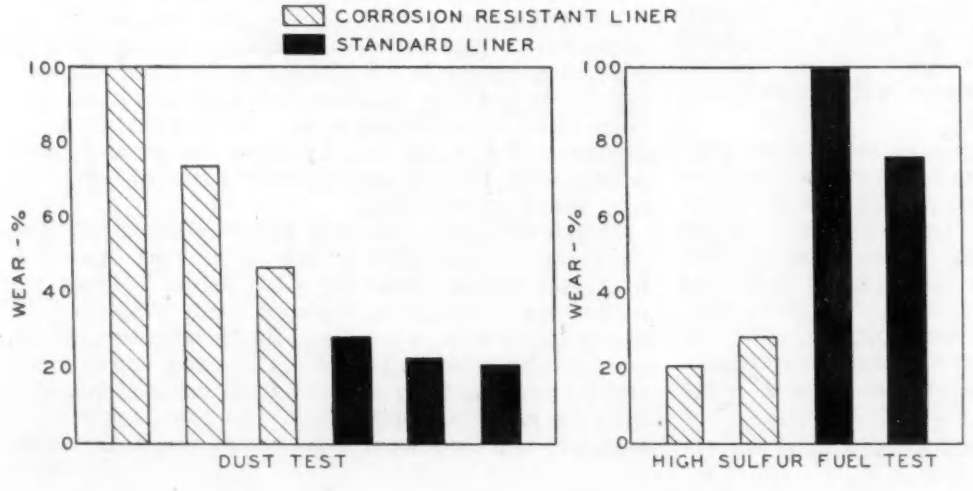
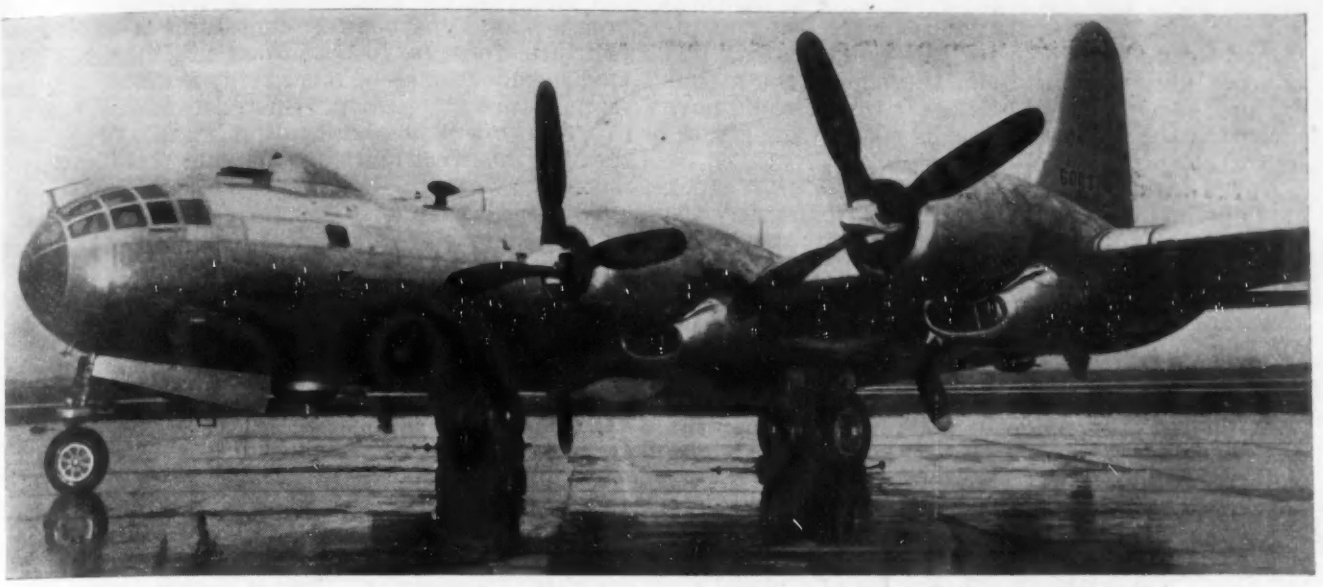


Fig. 8—While a particular material may be suitable for resisting corrosion, it may be inferior from an abrasion standpoint these charts show



Boeing's requirement of one oil and one grease for the B-50 Superfortress exemplifies . . . . .

The Air Force's Lube Program Objectives

EXCERPTS FROM PAPER* BY

E. M. Glass

Chief, Petroleum Products Unit, Materials Laboratory, Engineering Division, Air Materiel Command

THE Air Force lubrication program aims at flexibility which will keep lubricants and rapidly-advancing aircraft in step, while keeping to a minimum the number of lubricants. Closer cooperation between design engineers and lubrication engineers plus a 95% reduction in the number of lubricants carried—from 400 to 20—are two big benefits derived from the program. Backbone of the program is sound lubrication specifications.

In the not-too-distant past, lubrication of aircraft presented very few problems. The level of aircraft development was such that it was possible to visualize a single product, similar to automotive greases, which would satisfy all aircraft grease requirements —and a single oil to satisfy all oil needs.

Accelerated development of high-speed, long-range aircraft has made it imperative that lubricant development keep pace with the amazing technological advances in design engineering. These revolutionary developments have transformed lubrication of military aircraft from a relatively simple stage to an extremely complex phase.

Supply and logistic problems of the Air Force, standardization of bearings, and the nature of aircraft procurement all justify a lubrication program.

A sound lubrication program is not a requirement peculiar to the military services, but a problem of great importance also to industry. A review of the literature clearly shows how closely the lubricant supply problems of the USAF generally parallel those of industry. For example, in a lubrication survey made by the West Penn Power Co. on equipment in a central power station, it was found that 41 differ-

* Paper "Lubrication Engineering—the United States Air Forces Approach," was presented at SAE National Fuels and Lubricants Meeting, Tulsa, Nov. 4, 1948. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.

ent oils and 22 different greases were being maintained in the storeroom for this equipment. When another unit was installed, the equipment manufacturer recommended lubricants which would have increased the number of oils by six and the greases by three.

At the beginning of World War II, the USAF stock catalogs maintained listings for approximately 400 special lubricants "required" for the aircraft equipment operated at that time. When both this company and the USAF contacted equipment manufacturers to ascertain the reason and the basis for the selection of lubricants, the same answers were received: These recommended lubricants had proved adequate in the equipment. In many instances, no attempt had been made to determine whether the best lubricants had been selected or whether better methods of lubrication were indicated.

Due to the complexity of the United States Air Force, no civilian company or corporation can adequately be used for purposes of comparison from this point on. The satisfactory operation of a global air force with all of the ramifications of supply, logistics, and maintenance on a world wide scale is a staggering problem.

Whereas the West Penn Power Co. central power station maintains a relatively small number of personnel, who can be easily trained to operate and maintain stationary equipment, the Air Force had to rely on the good judgment of 780,000 military personnel and an unknown number of civilian personnel, many of whom did not even have the benefit of knowledge of the barest fundamentals of lubrication and lubricants. This, of course, can be attributed to the necessity for an accelerated training program during that period of emergency.

Further, they were scattered all over the world on lonely island outposts, in jungles, and in many other locations comprising 2300 different installations, maintaining 300,000 airplanes made up of 80 different models (not including the various modifications within a model), and loosely knit by lengthy and sometimes vulnerable supply lines. The magnitude of the work accomplished by this group of personnel is certainly removed from the spectacular when viewed in the form of statistics.

Prior to the war, the men that maintained aircraft were virtually all skilled mechanics, who not only maintained their equipment but performed lubrication. In these days of mass production and specialization, production line maintenance has been established by the military services to speed up the process. Low skilled and low pay personnel are usually assigned to such jobs as lubrication. Thus the simpler and the more automatic lubrication is made for such personnel, the better and more expeditiously this job can be performed. Limiting the number of lubricants required to be handled by maintenance personnel is a big step forward in this direction.

In addition to the logistics and supply problem for lubricants, there is the ever present problem of bearing standardization which is closely associated with the same problems under discussion. It is USAF and Navy policy to procure antifriction bearings as standard items, notwithstanding the type of application in which the bearing is installed.

It is quite evident that a pre-lubricated, double grease-plate type bearing containing a high temperature grease may—because of size, diameter, and load specifications—be mistakenly installed in a low temperature application. Such action would result in serious operational difficulties because of the fact that the incorrect lubricant may not function satisfactorily at extremely low temperatures.

To prevent such mistakes, the services have established separate stock numbers for single bearings having the same boundary dimensions but containing different lubricants. In other words for a particular double grease-plate bearing there may be three stock numbers:

a. One for low-temperature grease (such as AN-G-25),

b. One for a medium-temperature grease (such as AN-G-15),

c. One for a high-temperature grease (such as AN-G-5a).

Unless lubricants were properly standardized, there would be need for 15 or 20 stock numbers for one particular bearing. This of course could not be tolerated.

It is pertinent at this time to outline briefly the development program generally followed by the military services to obtain an end item of equipment. Of course, the entire program has been over-simplified here for illustration purposes. Normally, the military requirements for aircraft equipment are first established and, if these cannot be met with commercially available equipment, industry then is contacted for the purpose of designing such equipment as will meet these requirements.

An experimental item usually is fabricated and exhaustive tests conducted both by industry and the services to determine military suitability. Modifications are made on promising items and possibly several of these items are procured on a service test basis.

After the performance of these items has been approved—with possible additional modification—the next phase is production for limited or general use by the military services.

The time element from drawing board to production of military aircraft equipment varies widely—five or more years being necessary for an airplane such as the B-29 or the B-36. During all of these phases of evaluation, testing has normally been accomplished with the lubricants, chosen by the contractor. Since contractors have been under no real compulsion to use standard lubricants in their items, either the Air Force has been required to adopt the lubricants used by the contractors, or to institute costly and lengthy programs of evaluating standard lubricants in the same equipment heretofore evaluated only with proprietary lubricants.

During the recent war, the Air Force attempted to insure the proper lubrication of aircraft in the main by the dissemination of adequate and simple lubrication instructions to concerned personnel in the field. While this was desirable and even imperative, it soon became apparent that such a program in itself was insufficient. Major efforts were expended in determining specification substitutes for proprietary lubricants recommended by contractors after production items were in the field. After considerable experience under these conditions, the need for adequate provisions to simplify and standardize lubri-

cation during the design or development stages rather than after full production had been attained were graphically illustrated.

It may then be concluded that standardization of lubricants so that the least number need be procured, supplied, and used is a worth while and necessary goal and any program able to accomplish this purpose is well founded.

Other objectives also are gained. It has been reported that petroleum products constituted 50% of all tonnage shipped overseas during the last war. Any acceptable standardization program would reduce shipment and handling problems to a bare minimum.

Finally, one of the most important advantages derived from a sound lubrication engineering program is the benefit derived from the close cooperation between design engineers and lubrication engineers with the resultant greater probability of more efficient aircraft equipment.

Lubrication Program

The entire progrem of lubrication engineering as practiced by the United States Air Force is covered by Specification AN-L-32, General Specification for the Lubrication of Aircraft. This specification was promulgated through the combined efforts of the Bureau of Aeronautics and the United States Air Force and was issued Sept. 12, 1945. The fact that this specification is a contractual requirement for all experimental, service test, and production equipment being procured by the Air Force indicates the unusual importance placed on lubrication by the USAF.

Key to the program is the basis for the selection of lubricants by equipment manufacturers for aircraft and components procured by the USAF. The equipment manufacturers are required to select lubricants on the basis of (a) performance and/or other test requirements of the detail specifications covering aircraft equipment and components requiring lubrication, or (b) current practice proven satisfactory in the field. It is required that the selection of lubricants be made from Air Force-Navy Bulletin No. 275 which lists those specification lubricants that are standard items and already stocked at all USAF installations. (Table 1, on pp. 48-49, lists those lubricants given in ANA Bulletin 275.)

The perils of premature or hastily conceived standardization are certainly well known and both military and industrial leaders continually have pointed out the dangers of hamstringing development work by "freezing" designs too early. Germany standardized aircraft design early in the war and, while production benefited, technical superiority passed to the Allies, who constantly changed and improved their basic designs.

With this thought in mind and the fact that those lubricants listed in Bulletin 275 probably will not be able to satisfy all of the performance requirements of any equipment developed in the future, each USAF contractor has the opportunity to use lubricants other than those stocked by the United States Air Force, provided he complies with the following prerequisites:

a) Adequate data must be submitted to the Air Force indicating the unsatisfactory performance of the lubricants listed in ANA Bulletin 275.

b) Adequate data must be submitted to the United States Air Force indicating the satisfactory performance of the nonstandard lubricant selected.

The program is monitored by Air Force lubrication engineers who examine detail lubrication lists, submitted by equipment manufacturers, which furnish information regarding lubricants used in production, quantity used (where applicable), and application points such as type of bearing or gears. Substantiating data also are required in addition to the lubrication lists indicating that the lubricants selected will permit the aircraft or equipment to meet all of the detail requirements of the equipment specification affected by lubrication.

It may be seen that even though the contractor selects lubricants from the ANA bulletin, he still is required to accept all responsibility with respect to the suitability of the standard lubricant selected. Contractors also are urged and required to keep the number of different lubricants used on a given airplane or aircraft equipment to a minimum even though standard lubricants are used throughout.

A good example of how effectively this can be accomplished is the approach to lubrication of the B-50 Superfortress by the Boeing Aircraft Co. A lubrication list submitted by this Company indicates that one grease and one oil can be used for the lubrication of almost all of the lubricated parts of this complex and intricate airplane.

Other requirements of this specification define standard operating procedure and furnish government inspectors with a guide for maintaining quality control as pertaining to lubricants and lubrication.

Lube Specs Described

Any usable program for the selection and application of lubricants by the military services must be based on sound and practical lubricant specifications. It is my firm belief, supported by performance data, that the lubricants listed in Table I comply with these requirements. It cannot be inferred, however, that these lubricants represent the final answer to the USAF's needs. Present and future design aircraft and aircraft components already have stressed the need for additional improvements in these specification lubricants.

Lubricants and hydraulic fluids presently specified by the USAF are as follows:

- *Specification AN-G-25, Grease, Lubricating, Low Temperature (Low Volatility)*—

This is the first synthetic grease used in major aircraft applications. It utilizes diesters (6-10 carbon atoms) and low viscosity glycol derivatives as synthetic oil components. Similar greases containing silicone oils are under investigation. This grease was developed to eliminate the undesirable characteristics of Specification AN-G-3 greases, particularly with regard to bleeding, evaporation, and shear stability, while retaining the desirable characteristics of a good low-temperature grease.

The excellent high-temperature properties (250-300F) of this grease coupled with its excellent low temperature (-65F) characteristics make this synthetic grease potentially a universal grease for military aircraft. Some improvement in the wear char-

acteristics is still required and a further extension of the temperature range is indicated before this goal could be realized.

• *Specification AN-G-15, Grease, Lubricating, General Purpose—*

This grease was developed as a general purpose grease to be used primarily for major aircraft applications (other than control bearings) and has been used for most routine maintenance requirements. Prior to the development of Specification AN-G-25 grease, this grease performed ideally in applications where Specification AN-G-3 grease appeared inadequate. This general purpose grease, however, is being gradually displaced by Specification AN-G-25 and the future may well see the complete elimination of this grease in conventional aircraft applications.

• *Specification AN-G-5a, Grease, High Temperature, Water Resistant—*

It is used primarily for the lubrication of hot running equipment such as generators and alternators, where low temperature torque is relatively unimportant. This grease has performed adequately in presently designed equipment, although the trend toward higher temperatures in silicone-insulated motors and the higher temperatures anticipated with transonic and supersonic aircraft will probably require a search for more suitable high-temperature lubricants.

• *Specification AN-G-10 Grease, Extreme Pressure, Low Temperature, Lubricating—*

This grease has properties similar to Specification AN-G-3 grease, except that an extreme pressure additive has been incorporated. The greases described by this specification exhibit all of the shortcomings of Specification AN-G-3. Superseding this specification with an antiwear or EP version of Specification AN-G-25 has been under consideration by the USAF and the Navy Bureau of Aeronautics for some time. Preliminary data indicate that the EP version may be adopted, particularly in view of the high load support requirements of certain aircraft actuators.

• *Specification AN-G-6a, Grease, Lubricating, Graphite—*

This grease has extremely limited applications in military aircraft. It was primarily developed for starter gears, other gears and chains, where only very infrequent lubrication is possible. The "-a" revision to this specification described a grease consisting of Specification AN-G-15 to which has been added 5% by weight of graphite. Data obtained to date indicate that the bleeding characteristics when used on high speed starter gears to be somewhat objectionable. This problem is under investigation.

• *Specification AN-O-3, Oil, Low Temperature, Lubricating, Gear—*

This oil is intended for use in gear boxes where extreme pressure properties are required. It has the disadvantage of two grades, serious attack on bronze, and relatively poor thermal and oxidation stability.

Table 1—Specification Lubricants Used

Symbol	Product	Specification & Grades
CAS	Compound; Anti-Seize, White Lead-Base	AN-C-53
CO	Compound; Anti-Seize and Sealing (for Oxygen Systems)	AN-C-86
CSP	Compound; Anti-Seize, Graphite-Petrolatum	AN-C-147
CEC	Compound; Corrosion-Preventive, Aircraft Engine	AN-VV-C-576
CLT	Grease; Low Temperature Aircraft Lubricating (Low Volatility Type)	AN-G-25
GRG	Grease; Gasoline and Oil Resistant	AN-G-14
GB	Grease; General Purpose, Aircraft Lubricating	AN-G-15
FG	Graphite; Lubricating	AN-G-24
OGR	Oil; Low Temperature, Lubricating, Gear	AN-0-3
OGP	Oil; General Purpose, Low Temperature, Lubricating	AN-0-6
GH	Grease; High Temperature, Water Resistant	AN-G-5
GG	Grease; Lubricating Graphite	AN-G-6
GLE	Grease; Extreme Pressure Low Temperature Lubricating	AN-G-10
OHA	Oil; Hydraulic Petroleum Base	AN-0-366
OHC	Oil; Preservative (for Hydraulic Equipment)	AN-0-7
OEA	Oil; Lubricating Aircraft Engine	AN-0-8, 1065, 1080, 1100, 1120
GO	Lubricant, Gear, Universal	VV-L-761 SAE80, SAE90
OJE	Oil; Jet Engine	AN-0-9 1010, 1015
OPR	Oil; Lubricating and Preserving	AN-0-10
OAI	Oil; Lubricating, Aircraft Instrument (Low Volatility)	AN-0-11

Supersedes	Applicable ANA Bulletin	General Application
AN-9516	...	General purpose anti-seize compound for threaded connections. (Except for oxygen systems and straight threads on hydraulic system and similar fittings.)
...	174	Anti-Seize compound for oxygen system connections (non-inflammable).
AN-VV-C-566 USAF 3578 AN-9514	...	Anti-Seize compound for spark plug threads.
AN-9808	138	Corrosion preventive for aircraft engines used as engine preservative and flyaway oil. Use as required by Specification AN-P-64, AN-C-80, and AN-E-11.
AN-G-3	308	An improved low temperature grease suitable for all applications where GL has previously been used such as control bearings, actuators, universals, camera bearings, auto pilot rotor bearings, flexible shafts and in addition is suitable for gear boxes, high speed intermittent or continuous duty motors operating at both low and high temperatures. Improved characteristics include low evaporation rate and unusual stability with regard to any tendency to liquefy and foam in a bearing or gear box. Estimated operating temperature range −54°C (−65°F) to 121°C (250°F). CAUTION: This grease contains a non-petroleum component which may soften paint, natural rubber or neoprene with which it comes in contact.
2-85-B, L-17	...	Recommended where a petroleum resistant lubricating, anti-seize, or gasket sealing material is required. Not suitable for low temperature operation where torque is critical.
USAF 3560, medium grade	247	Antifriction bearings, gears, and other mechanisms operating at high speeds and medium temperatures. Most electrical equipment bearings, magneto gears, starter bearing, landing gear support members, propeller hubs and for most routine maintenance requirements. Adequate at low temperatures if sufficient torque is available for starting. Water resistant. Estimated normal operating temperature range −40°C (−40°F) to +121°C (+250°F). Where sufficient torque is available, may be used down to −54°C (−65°F). Where low temperature torque is critical, use GLT.
2-64	...	Mix with AN-0-10 or AN-0-6 for wet starter clutches and other applications where graphite oil is required.
Y-3587	158	Separately lubricated engine reduction gears and other gear boxes where oil can be retained and better load carrying capacity than provided by uncompounded oil is required.
2-27	263	General "squirt can" lubrication. Other applications where a very light, low temperature, corrosion-resistant oil lubricant is required, such as for cameras, radio and radar equipment, Curtiss-Electric propeller reduction gears. Evaporation will limit application at high temperature unless provision is made for frequent relubrication. See Specification 3608.
USAF 3560 hard grade	151	Antifriction bearings and related applications for high speed, high temperature operation, and where water resistance is a factor. Lubrication of wheel bearing, and lubrication of hot-running electrical equipment where sufficient torque is available at low temperatures to insure operation. Estimate operating temperature range −18°C (0°F) to +149°C (+300°F) where low torque is available. Suitable down to −54°C (−65°F) in applications such as generator and wheel bearings.
USAF 3607	345	Applications where only very infrequent lubrication is possible and where graphite will lubricate in case all other lubricant is lost. Not generally suitable for extreme high or low temperatures. Not recommended for electric equipment or antifriction bearing.
...	167	Gears, screws, worm sprockets, and chains where low temperature torque is important and where better load carrying capacity than that provided by AN-G-25 is required. Estimated operating temperature range −54°C (−65°F) to +80°C (+175°F). An improved lubricant of this type is under development which will exhibit, in addition, many of the desirable features of Specification AN-G-25.
AN-VV-0-366	111	Hydraulic system and shock strut fluid. Suitable for all temperatures. Requires adequate packing materials.
USAF 3605	...	Corrosion-preventative oil for filling struts and hydraulic systems parts for storage after manufacture.
AN9532, 2-91 AN-VV-0-446	329	Aircraft engines, in accordance with Specifications AN9500, AN-P-64, and AN-T-25, can be used also where heavier grades of oil are required for general lubrication when low temperature characteristics need not be considered.
2-105	...	Use where heavier E.P. oil than covered by AN-0-3 is required. Example, SAE90 in Magneto shaft seal.
USAF 3606	327	Turbo-jet engines, turbo superchargers, and air compressors. Can be used where a light, non-compounded mineral oil with good low temperature properties is required.
USAF 3582	332	In applications where an SAE 10 rust preventive oil is required but is not to be used for crankcase lubrication of auxiliary equipment.
USAF 3608	348	In aircraft instruments and electronic equipment or in applications where evaporation limits the suitability of OGP. CAUTION: This oil contains a non-petroleum component which may soften paint, natural rubber, or neoprene with which it comes in contact.

A single, all temperature oil is under consideration at the present time, particularly with regard to possible use in helicopter gear boxes, B-36 and B-49 constant speed alternator drives, and prop-jet engines. Improvement of other deficiencies also is under investigation.

- *Specification AN-O-6a, Oil, General Purpose, Low Temperature, Lubricating—*

This is the first low-temperature, oxidation and rust inhibitor-containing lubricating oil developed for general squirt can and instrument use in aircraft. Its greatest limitation has been poor volatility characteristics, with resultant relegation to applications with relatively low operating temperatures. Due to this failing and its relatively poor foaming characteristics, greater stress is being placed on the use of synthetic oils such as described by Specification AN-O-11.

- *Specification AN-O-8, Oil, Lubricating Aircraft Engine—*

AN-O-8 has been in use in aircraft reciprocating engines for a number of years with no marked deficiencies other than poor low-temperature starting characteristics. The present trend toward jet and rocket aircraft will result in a minor role for this oil in the future. However, work is continuing to develop an oil with better crankability characteristics at -65F.

- *Specification AN-O-9, Oil, Jet Engine—*

Used in all production jet engines to date, this oil has given satisfactory results. Major failings appear to be relatively poor volatility and low temperature viscosity properties. Development work is underway to improve both. Possible utilization of additives such as pour depressants and VI improvers and incorporation of nonhydrocarbon components are being investigated.

- *Specification AN-O-10, Oil, Lubricating and Preserving—*

AN-O-10 is an SAE 10 rust-preventive oil containing VI improver; it has very few major applications in aircraft. Its most important use at the present time is Aeroproducts Propeller regulator, although it is being supplanted by Specification AN-O-366 in this application. Major limitations are – 50F pour point and relatively poor viscosity temperature characteristics.

- *Specification AN-O-11, Oil, Lubricating, Aircraft Instrument (Low Volatility)—*

A synthetic oil of the diester type, AN-O-11 is particularly useful in aircraft instruments, cameras, and electronic equipment. To date only 2-Ethyl Hexyl Sebacate base oils have been approved under the specification, although Ucon fluids and esters of adipic acid, azeleic acid, and other dibasic acid esters are being investigated at the present time.

This type instrument oil has been in use for approximately five years by the USAF with an excellent performance record. Investigation of the oxidation characteristics of this oil in the presence of large areas of various metal catalysts is under way. This program has been initiated as a result of field service reports which indicate possible thickening of the lubricant in service under extremely thin film conditions. Some corrosion difficulties have been reported where brass and steel couples are present.

- *Specification AN-O-366, Oil, Hydraulic, Petroleum Base—*

This is an "all temperature" aircraft hydraulic fluid which has given outstanding service in all military aircraft since 1943. Major efforts are toward improvement of nonflammability characteristics[1] and high-temperature characteristics without affecting the low-temperature properties and other performance properties.

Benefits of the Lubrication Program

The lubrication program outlined has been in effect for approximately three years and it is now possible to evaluate the results of this comprehensive program.

It has been possible to reduce the number of lubricants in stock from the 400 special lubricants mentioned to approximately 20. This unusual reduction of lubricants has greatly simplified field maintenance, supply, transportation, and procurement and has undoubtedly reduced the costs involved in the lubrication of aircraft and its components to a marked degree. Since very few cases have arisen since the promulgation of this specification where standard lubricants have not been able to perform adequately in procured equipment, no special procurements or special handling of lubricants have been necessary.

Simplification of lubricant selection and application makes it possible to train personnel in aircraft lubrication within very short periods of time and will insure that errors in the application of lubricants in the field will be practically negligible.

Reduction of the number of lubricants required has resulted in unusual savings in bearing costs; it has insured that bearing stocks will be maintained at proper levels without constituting a drain on such a critical item during such short supply levels, as are being experienced at the present time and are always experienced during war time.

The program has placed great emphasis on the evaluation of lubricants and lubrication to parallel equipment development from the drawing board to the production item.

The lubrication program practiced by the USAF has derived one of the most basic benefits upon which all others are based—the welding together of a partnership between the design engineer and the lubrication engineer. The result: aircraft equipment both mechanically engineered and lubrication engineered in the mutual creation of an Air Force second to none.

[1] For additional details regarding less flammable aircraft hydraulic fluids, see SAE Journal, September, 1948, pp. 55-59; "What the Air Force Wants in Nonflammable Hydraulic Fluids," by E. M. Glass.

Program for Simpler Aircraft Systems

BASED ON PAPER* BY

L. R. Koepnick

Chief Engineer, Trans World Airline

THE way to reverse the trend toward increasing complexity in airplane operating systems is for airlines and aircraft manufacturers to make a concerted attack on the problem before and during the design of future transports.

In this era when aircraft systems, rather than aerodynamics or structures, give the most trouble, design of systems deserves a major share of attention from manufacturers and customers. Unnecessary complication must be eliminated from the design. Each operating system must be designed, tested, and developed just as carefully and completely as the airframe structure.

Outline of Program

Here is an eight-point program for developing systems of minimum complexity for new airplanes:

1. Airlines should review their requirements and prune away unnecessary ones. Minimum requirements as well as desired attainment should be specified.

The fact that removal of automatic oil-temperature shutter controls, automatic pressure regulators, and other automatic gadgets by airline maintenance departments has been well received by operations departments proves that the original requirements established for some systems were far above actual minimum requirements. Ordering, then removing, gadgets is a very expensive process. Not only was the gadget paid for in the initial price of the airplane, but also its engineering costs were paid, spares purchased, costly delays and other unsatisfactory conditions endured as long as possible, and removal costs paid. The time to simplify is when requirements are being drawn up.

2. Airlines ordering a particular model airplane must agree among themselves on requirements for operating systems. If the manufacturer is going to put as much emphasis on operating systems as on structures, his designs must be considered just about optimum, and there will be no logical reason for differences in requirements among airlines.

The alternative to standardization between airlines may be detailed government regulations covering design, testing, and development of aircraft systems, similar to the regulations which exist now for structures, aerodynamics, and performance—and neither airlines nor manufacturers want more regulations.

3. Designers of systems must make simplicity their goal.

Simplicity implies segregation. Segregated systems are easier to check and repair. They are safer, too. Electrical and hydraulic systems particularly need separation so that flammable hydraulic fluid will have no chance to spread electrical fires. Designers should allow for segregation in figuring space requirements. Then their space estimates should be heeded by those who are designing the airframe.

From the maintenance point of view, grouping a number of functional items of one system into a package designed for quick removal and replacement is another step toward simplification. With this arrangement, it is not necessary to trouble-shoot a system to determine which item is causing trouble. A malfunctioning package is removed and a satisfactory one installed.

Penalty for speedy repair is larger inventories. For example, spare heater panels provisioned by TWA for one model in their fleet cost a little over $100,000. If the system had not been packaged, only about $25,000-worth of heating-system components would have to be stocked. The penalty for rapid repair of the heating system of only one model of airplane is $75,000 tied up in stock items.

In the drive for simplicity, manual operation should be considered in many cases where auto-

* Paper "Simplicity as a Goal in the Design of Aircraft Systems" was presented at the SAE National Aeronautic Meeting, New York, April 13, 1948. Complete paper on which this article is based is available from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.

matic operation is provided in today's designs. Besides relative complexity, designers should compare cost, performance, and weight for the two methods of operation. Unless automaticity shows definite advantage, manual operation should be employed.

4. Manufacturers should present specifications, diagrams, and parts lists of systems to prospective customers for review and approval before detail drawings are completed. If the customers consider a system too complicated, the manufacturer should redesign it.

5. Individual items of each system should be laboratory tested. Installation of unproved equipment only causes trouble.

Mock-Ups Needed

6. Each system should be built up completely to scale to permit complete functional testing as well as to ensure that it takes no more than the allotted space. The test program should check the program under all conceivable conditions of operation and combinations of failures of individual items of the system.

The value of mocking up a system was proved in the development of the Constellation hydraulic system. Lockheed engineers realized that the hydraulic system would be the heart of the Constellation because it operates flight control surfaces as well as performs the many functions normally handled by hydraulic systems. They built an elaborate mock-up of the hydraulic system, actually a full-scale working model. Four V-8 engines powered the system. From a cockpit in the Lockheed Research Department, it was possible to fly the mock-up, operating the flight control system by hydraulic boost against loads equal to the aerodynamic loads. Also, it was possible to steer the nose wheel, retract the landing gear, operate the flaps, and operate the automatic pilot—all against loads duplicating those which would be imposed in the actual airplane.

This mock-up enabled Lockheed engineers to check a number of conditions they designated "What-Ifs," such as "what if" one hydraulic pump fails or "what if" the line to the inboard flap cylinder ruptures.

The result was that, complicated as the hydraulic system in the Constellation is, it caused much less trouble than simpler hydraulic systems in other airplanes had been causing.

7. The manufacturer should put each new model airplane through a thorough service test before releasing it to his production department.

Light-plane manufacturers' experience illustrates the wisdom of service testing. Before the Bonanza went into production, Beech built three prototypes and flew each one 1000 hr. Flaws were uncovered and corrected in the prototypes. As a result, there has not been a single CAA Mandatory Airworthiness Directive Note issued applying to the airplane's structure or any system except the powerplant. Of the two Notes applicable to the powerplant installation, as of Feb. 15, 1948, one specified a change in engine identification plate. A competitive airplane, not extensively service tested, had a total of 14 CAA Mandatory Notes issued against it in a similar period.

Northrop also followed the plan of building a prototype for extensive service testing with their Pioneer before accepting orders for it.

8. Manufacturers should see that their systems engineers have an understanding of airline operating and maintenance problems. The understanding can be acquired by visits to airline maintenance bases and overhaul shops, preferably before start of a design and at intervals of six months or less thereafter. It would help, too, if at least 5% of all new engineers hired had airline backgrounds.

Investigations Made On Stability and Control

Excerpts from paper by **MELVIN N. GOUGH** NACA

STABILITY and control characteristics of future transport aircraft should benefit from several recent investigations.

One investigation was made on a C-54 airplane to determine whether any additional requirements should be made to insure satisfactory stability and control characteristics during precision flying associated with instrument approaches and blind landings. It was found that an airplane which satisfied the requirements for stability and control already established would also be satisfactory for this operation.

The tests served also to emphasize the bad effects of excessive friction in the control system on controllability in precision flying. Excessive friction in the control system not only increased the pilot's effort but also impaired the response of the aircraft to control force applications to such an extent as to make the precision flying required in blind approaches extremely difficult.

The magnitude of the friction in the airplane design was quite acceptable, becoming objectionable only when improper automatic pilot installation and poor maintenance were included.

A study of means to reduce the acceleration experienced by an airplane in flight through rough air shows that sweepback is a promising means of improving the smoothness of flight.

Another possible method is operation of flaps or other controls by an automatic mechanism in such a way as to reduce the accelerations. (Paper "Flight Qualities and Performance," was presented at SAE National Aeronautic Meeting, Los Angeles, Oct. 9, 1948.)

ECONOMICS Shape TRUCK TRENDS

EXCERPTED FROM PAPER* BY

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GROWTH is one of the primary trends in motor truck design. Despite the restraining bonds of legislation, sheer economic necessity has steadily increased prevailing loads carried by over-the-road freighters, wholesale delivery trucks, coal trucks, tank outfits, beverage trucks, and off-the-highway mining, logging, earth-moving and oil field equipment.

In 1947 and 1948 new truck registrations of over 19,500 lb gvw were 47 times as great as in 1940. Then only 1 1/3% of all new trucks delivered in this country were over 19,500 lb gvw rating. Today these constitute nearly 15%.

There is small likelihood of trucks becoming too large or too heavy. Their cumbrousness would prevent effective use. Economics will also prevent excessive size.

If trucks are too small, too frail or too slow to fulfill their mission, then they will be made larger, stronger and more powerful. But this growth will be governed by the inexorable workings of the law of diminishing returns. A point is eventually reached where cost and inconvenience of operation exceeds productive gain. At that point the incentive for size, weight and power increase disappears.

Economic conditions today demand unprecedented large capacities and good performance, and producers are diligently endeavoring to meet it. Some efforts are meeting with greater success than others and experience with the various offerings resulting from these attempts is crystallizing engineering development in trends. All, in the last analysis, are simply reflections of economic dictation.

There is a parallel trend toward improved performance—not necessarily higher maximum speed but, through better grade ability and correspondingly improved acceleration, higher average running speed. This demands more effective brakes and steering for safety.

Comfort and convenience of the cab and controls, heating and ventilation, reduction of noise and vibration, and improvement of riding qualities are reducing driver fatigue and hence important economic factors for the truck operator.

Emergencies created by today's inflationary trends have placed heavy responsibilities upon designers and producers of motor trucks. A great deal of development is evident in current production, but most will not appear until next year and later. Throughout this development, certain trends are clearly discernible which show unmistakably that their inspiration is predominantly economic. True, style fads which bear little relation to economics have arisen, but these we can ignore.

Some economic influences on truck design are not permitted directly because of legislative restraints. However, certain legislative restraints are largely economic in origin.

Thus the predominance of the tractor-semi-trailer in long-distance motor freighting is due principally to legislation and regulation in most of the states granting to this type greater gross weight and length than a single vehicle equipped with the same number of axles. Were users permitted the same weight and body length on both types, the direct economics of highway transport would probably induce many inter-city haulers to operate large six-wheelers.

With things as they are, attractive features of the six-wheeler are receiving renewed recognition and demand for them is increasing. This will inevitably modify legislative determinations.

Outstanding among current trends is that toward greater horsepower for trucks. This is for better performance, and performance depends basically upon power. Special gearing will not increase power, though it may make more of it available. Maximum performance under any condition is obtained when the power of the engine is delivered to the driving wheels at exactly the right gear reduction, but this maximum can never exceed the engine's power potential.

Performance potential is the balance between the maximum power output of the engine and the gross weight of the vehicle or combination. In any vehicle maximum performance is realizable only when the gear-reduction exactly coincides with requirements as to speed, rolling resistance and grade.

The more gear-ratios available through the trans-

* Paper "Economics Shape Truck Trends" was presented at SAE Mid-Continent Section, Oklahoma, Oct. 12, 1948. Complete paper on which this article is based is available from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.

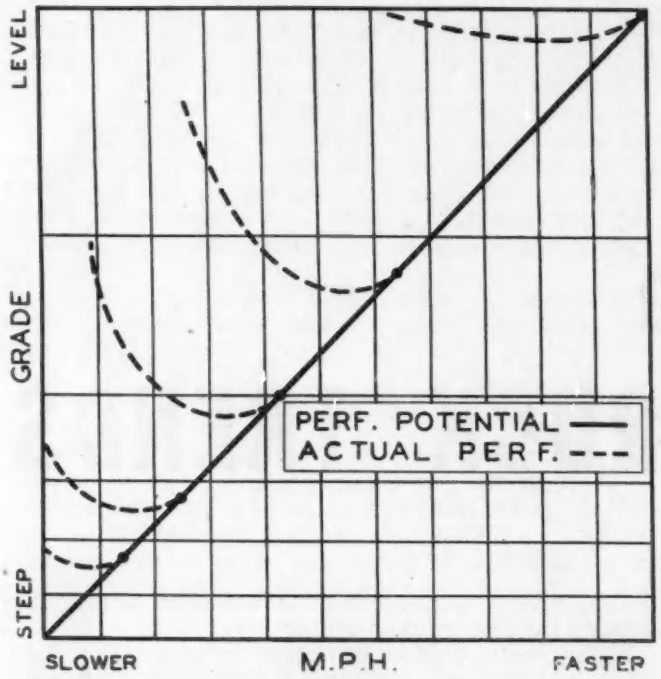


Fig. 1—Performance potential shown against actual performance of a vehicle with a five-speed transmission

mission and auxiliary gear-change mechanisms provided, the more different conditions may be met perfectly, and the closer approximation to potential performance may be reached between the points of coincidence.

Performance potential of a given vehicle as to speeds on different grades is illustrated by the full-line curve, and the actual performance ability charted in the broken-line curves, in Fig. 1. If we had twice as many shifts as shown here, we would have twice as many points where the actual performance ability coincided with the performance potential. Only an efficient infinitely-variable transmission would show actual performance equal throughout to potential performance.

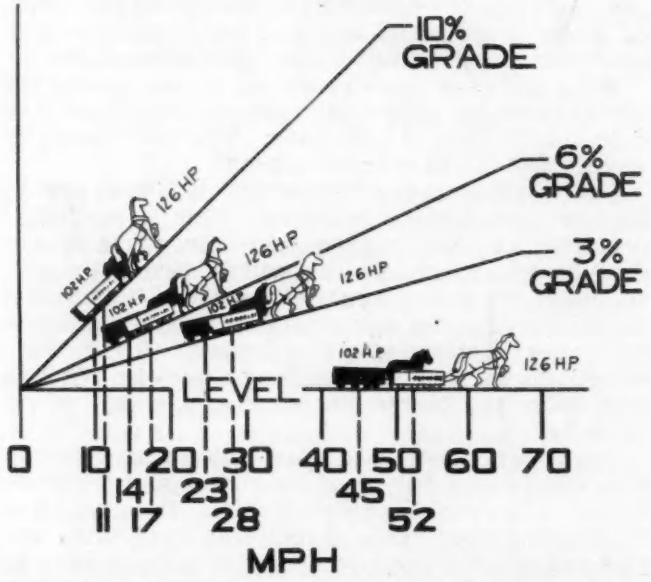


Fig. 2—Performance potentials of 102 hp and 126 hp engines, each with 40,000 lb gross weight, expressed in speed on various grades

How drastically power requirements are affected by increases in required performance is shown by Fig. 2.

Only in recent years it has been generally understood that often use of more powerful engines for given gross weights results in improved performance, ease of operation, and in economy of fuel and maintenance. Of two similar trucks, the more powerful is often the more economical in overall, long-run cost because the more powerful engines allow faster gear ratios, through which a better power factor may be maintained for the engine. It operates more of the time within the economy range. An engine is most economical when operating at full throttle below governed speed because then compression pressures are maintained. Furthermore, the faster ratios result in a lower number of engine turns per mile and therefore decrease wear of the engine and of all driving parts.

Higher torque in larger engines permits loads to be started and gear shifts to be made with less clutch slipping and less flywheeling. The larger engine also requires less range of ratios in the transmission system and offers greater flexibility within one ratio. This means less gearshifting and better acceleration.

However, there are limits. Because a 30% increase in horsepower results in, say, a 15% gain in economy, it does not follow that 60% more power will net a 30% rise in economy. Even where greater power offers an economy potential, expectations are not always realized.

Assumptions that bigger engines consume more fuel, require larger transmissions, driveshafts and rear axles—and hence need bigger frames, huskier front axles, and more powerful brakes—are much too broad in the face of actual experience.

Often greater engine power for the same gross weight does not mean higher fuel consumption, but in many cases, less. Transmission and axle size does not have to be increased in proportion to engine torque output where the gross weight remains the same. A large engine reduces the wear and maintenance on units of identical size in many cases.

Without a reaction, contrary and equal, there can be no action. The torque load which an engine may impose on the driving parts of a truck can therefore not exceed the torque resistance offered by the vehicle.

Equal weight under similar conditions will produce equal torque resistance, so that the more powerful engine can exert no greater maximum torque. But it improves performance because it exerts this maximum torque at a higher speed. For a given weight of wagon, a Percheron draft horse needs no heavier traces than a Morgan coach horse.

Moreover, the engine need not be heavier in proportion to its greater hp output. Most manufacturers build their engines in families, in which different displacements are provided in the same basic engines. The larger may have 20% more output than the smaller. As engines are refined constant increases in output are being made. In one, with no material increase in weight, its power increased from 75 to 121 hp in 18 years. This increase may not be duplicated in the years to follow, but specific horsepower is on the increase and specific weight is definitely going down.

Increased horsepower involves some increase in weight and when gross weight is already up to the maximum allowed by law, such increase inevitably decreases the maximum payload. Extra power permits more weight to be moved at the same speed as readily as it allows the same weight to be moved at higher speeds, Fig. 3.

Today 300 hp seems to be the limit for any size of highway vehicle, largely because of the restricted availability of practicable engines of greater output. But if the economic justification of higher output were established, engines would be forthcoming to supply that demand.

Current accelerated pace of engine development is bound to continue and specific power or specific weights for conventional gasoline engines have not been reached. Fuel injection may give us a slight gain in power and perhaps gratifying thriftiness of fuel. By refinement of design, constantly finer balance and countless minor betterments in processes, materials and treatments, stauncher engines of somewhat lower weight may be anticipated. These will bring economies, but other improvements of undoubted effectiveness will be shelved because their cost cannot be justified.

Nothing indicates that the diesel is a threat to the predominance of the gasoline engine in the common run of motor vehicles. Up to the present it offers economy of fuel. Except in well-managed fleets of 10 or more vehicles, it is apt to cost more for maintenance than a gasoline engine. It will certainly weigh more and to date no diesel has flexibility equal to gasoline engine standards.

It uses about 43% less fuel and that costs about 11% less than gasoline. Taken together, these make the per-mile fuel cost of the diesel a little over half that of the gasoline truck.

Rate of fuel consumption by long distance trucking, excavating dumpers and off-highway vehicles exceeds those in local haulage and delivery. But dependable diesels do not yet deliver specific power equivalent to gasoline engines of comparable size and weight, and care must be observed to avoid under-powering. Diesels need special driving methods, in many cases earlier shifting, and at all times close watch of the tachometer. Above all the paramount necessity of adequate facilities and qualified personnel for maintenance must not be overlooked if the inherent economy of the diesel is to be realized.

With the trend to greater power has come increased interest in multi-speed arrangements for the drive. Except in the lighter sizes and the heavier ones as used in local service, the conventional five-speed transmission seems inadequate for the more strenuous services. Consequently transmission development has proceeded along two principal lines:

Increase of total range of available ratios, and

Decrease of interval between successive steps, which necessitates more steps.

Among approaches to the problem are the two-speed axles—largely for the lighter vehicles. The basic four or five transmission shifts are duplicated in connection with a slower final reduction, thus doubling the number of forward and reverse shifts. Much the same result is accomplished by an auxiliary gearbox between the transmission and the driving axle. These sometimes provide an overgear, a direct, and an undergear.

A third alternative, more recently introduced, combines the compound with the main transmission to form a single-unit Duplex transmission, affording 10 forward speeds.

Some have the auxiliary steps placed quite close together, so that the lower range fits into the intervals between the upper range to form a complete series of half steps. Thus a ratio closely approximating the ideal to obtain the performance potential for any circumstance may be found. This makes a noticeable difference in running time, particularly in hilly country, on soft roads, or in congested traffic and also makes a difference in engine loading. The long step more often results in the engine running on the governor, at low economy, than the short step.

For runs in mountainous country and in dump truck and off-highway service where rolling resistances are high, the long-step arrangement is pref-

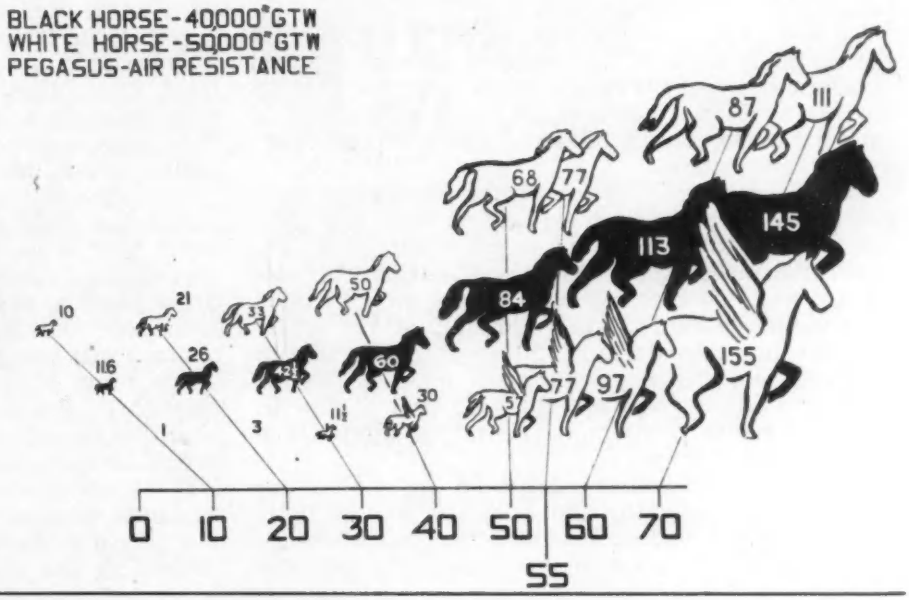


Fig. 3—Effect of difference in gvw on all tractive resistances other than air resistance, and power required to overcome air resistance independently of gross weight at various speeds on level concrete

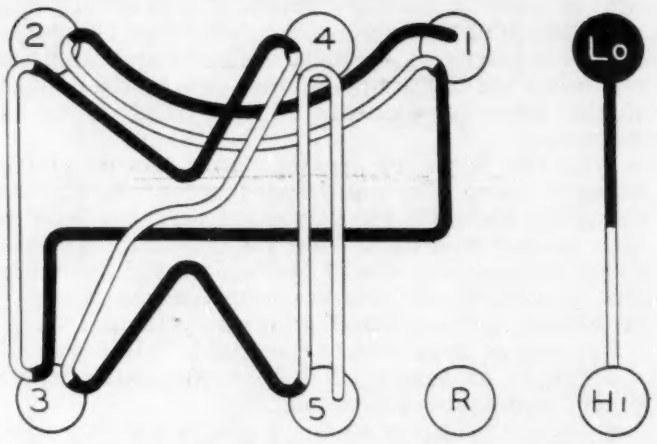


Fig. 4—Complicated shifting required for logical progression with two-lever shift and poorly integrated compound and main box ratios

erable. Here the low range is drastically slower than the high range, but the even splitting of the main box steps into half-steps has been lost. Some of the steps are so short they are useless, and the number of useful steps, instead of being doubled, may be increased by only one or two.

Three-speed auxiliaries are therefore often the only solution where the requirements are exceptionally severe. While these greatly increase the weight and complication and produce a large number of back-steps and virtual duplications of ratio, they extend the range to suit the most stringent demands. They also permit an expert driver to select a ratio which will closely approach the maximum performance potential for every condition.

One of the many suggestions made by thoughtful operators to simplify the rather terrifying intricacy of the two lever control in which the logical sequence of speeds departs from any reasonable shift pattern, Fig. 4, is to gather the main box ratios into a range with steps between 1 1/4 and 1 1/3 to 1, followed by a compound box with a step or steps so wide that the top speed of the low range would be just this interval below the bottom speed of the high range. Unfortunately no one seems to know how such a radical step could be shifted. This involves compound shifts of 4.15 to 1, Fig. 5.

By any means now known of, such shifts could not be made because they involve an engine speed difference beyond the range of any large, heavy-duty engines available, and because the inertia shock of such a radical change in shaft rpm would be enormously destructive.

Various combinations of torque converters with gearboxes have been experimented with and may yet develop to a point of practicability. In the meantime, power-shifted compounds are in successful use whereby a ten-speed box may be controlled by a single gearshift lever and half of the shifts may be pre-selected and power-shifted through synchronized shifting clutches. Possibilities of planetary gearing are re-explored, with a view to simplifying the problem of providing more steps within a wider range.

Extremely interesting results in weight saving have been achieved by the scientific use of light metals, whereby, within definite gross weight limitations, payload increases have been made possible which in some cases more than offset the additional costs. There is a renaissance of interest in all weight-saving materials and techniques, out of which much of permanent good is bound to arise. But the fanciful and impracticable will be eliminated by economics.

In general, weightsaving materials are deficient in stiffness, and aluminum and magnesium are disappointing in shock resistance and fatigue life and must be relegated to the low-stressed portions. Lack of hardness precludes their use in some applications, while electrolytic corrosion prevents their combination with ferrous metals, so weight saving is often insufficient to justify the higher cost, greater difficulty of repair and shorter life. In body and cab, however, they offer attractive possibilities.

Power braking is not the whole answer. Far greater attention must be paid to the proper balance of braking force between the axles, and their timing and response. Air brakes are putting up a vigorous fight to retain their supremacy against the threat of accumulator-type hydraulic powerbrakes and the continual improvement of the electrically-controlled self-energizing brake.

The foundation braking system itself is receiving much-needed development. Present trends are toward stiffer shoes and heavier drums, more rigid shoe and camshaft anchorages and lower-friction cams. There is a steady retreat from full-coverage brakes because it is now known that only a portion of the lining length can be really effective, regardless of its extent, and that exposed inner surface of the drum is one of the most effective means of heat dissipation.

With the increasing width of tires, intensified by the popularity of wide-base rims, finding enough room for large brakes is becoming constantly more difficult. The Army is trying out brakes located outboard of the wheels and there is much interest in disc-type brakes which have progressed so far in aviation practice.

Absorption of energy in descending grades is becoming more grave. Engines have distinct limitations as power absorbers and sustain no small amount of needless wear and stress in long descents in the lower gears. Loggers have had some success with water-spraying the wheel brakes, but supplementing the friction brakes is greatly to be desired. Two systems of retardation have been developed to meet this situation, namely the hydraulic pump type retarder and the electric eddy-current type. Both impose the penalty of extra weight and considerable cost, but open a most attractive field for further development.

Steering offers fruitful opportunity for improvement that is an economic necessity. Responsive, dependable and shock-proof steering without the tiring physical effort is essential if the full performance potentialities of modern vehicles are to be realized with safety.

The limit of manual operation has about been reached in the larger vehicles and has been considerably exceeded in ponderous off-highway types. Hydraulic servo power is satisfactory.

Truck operators are increasingly conscious of the economic value of comforts for the driver. Nervous and physical stress on the driver tend to be increased by the accelerated tempo and greater ex-

penditure of skill and effort required because of increases in the size, weight and speed of trucks.

Cabs are roomier and drivers' seats adjustable. Many drivers' seats have suspension springs and hydraulic shock absorbers. Positioning hand and foot controls, and the steering wheel has been carefully studied to avoid cramped positions. Instrument placing has been worked out for better vision from the natural driving position. Windshields are larger and closer to the driver's face, thus broadening his vision. Windshield posts are smaller, and rear view vision has been generally improved.

Real air conditioning is still a long way off, but what some glamorize as air conditioning is rapidly appearing. This is forced ventilation and heating with fresh air. Some arrangements have appeared in which all heater intake air is fresh while others employ some percentage of recirculation. In view of the outstanding success of all-fresh systems in heating large-capacity, frequent-stop buses, utilizing cooling system heat from the same sized engines, it would seem that recirculation is wholly unnecessary.

Although gasoline-burning heaters are becoming increasingly popular in pleasure cars and as cargo heaters for truck bodies, there seems little reason for their use as cab heaters considering the abundant and continuous heat available from the engine cooling system.

Conventional defroster slots serve quite satisfactorily except in extremely cold weather. The conventional windshield wiper, however, does not perform so well under snow and sleet conditions. Opening-type windshields are definitely on the way out, while the pleasure-car-type ventilating wings on the door windows are rapidly coming to the fore.

Avoidance of extremes of temperature in the cab largely depends upon insulation. This must resist heat transfer from any direction. A well-insulated roof, dash, cowl, doors, toe-boards, floorboards, and back will not prevent heat rising from beneath the seat. Insulation is of almost equal value in reducing the noise level in the cab. This it does by preventing the creation of noise by the vibration of the cab parts, deadening the resonance of the cab to prevent its serving as an amplifier of sounds created by vibration of other parts of the chassis, and by shutting out external sounds.

Riding ease will probably always prove a constantly receding target. No matter how much progress manufacturers make, users will never be fully satisfied. In trucks and particularly tractor-trucks, the problem is baffling because of the tremendous variation in load on the springs on the one hand, and the definitely limited deflection which can be allowed in consideration of both stability and empty loading height.

Leaf springs offer the simplest and lightest complete suspension, because it eliminates joints, arms and rods.

However, the torsion bar type offers the possibility of a graduated deflection rate by the use of a short-radius crank arm connection and in addition it affords the possibility of ready adjustment of standing height, thus making practical the use of greater total deflections.

Another economics inspired trend is weight redistribution. Paradoxically, this is proceeding in

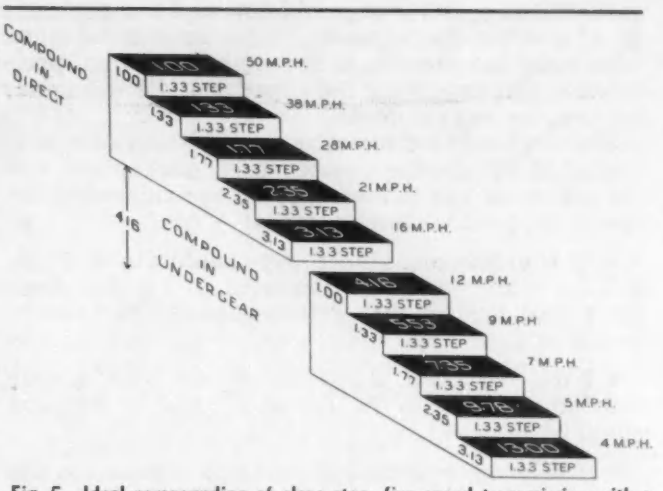


Fig. 5—Ideal compounding of close-step, five-speed transmission with a wide-step range shift, affording close and even progression, wide range and simple shifting. This is unattainable by known means

opposite directions. To attain the maximum gross weight allowable under axle weight limitations, the percentage of load carried by the front axle is being increased by setting it further back, thus permitting greater gvw without increasing rear axle weight beyond the limit. At the same time, to take full advantage of the bridge formula, in which the maximum gross weight depends upon axle spacing, front axles are being pushed further forward on some of the larger freighters, the capacity thus gained being cared for within axle weight limitations by increasing the number of axles.

The latter policy is purely legislative in origin, the former offering the additional advantages of shorter turning radius, somewhat lighter weight and more equitable distribution of weight on the tires, all of which are sacrificed in the artificial wheelbase lengthening suggested by the formula.

This is how legislative restrictions often influence truck design in direct opposition to economic dictates. These influences can reverse economic pressures serving to modify legislation in a manner conducive to more practical truck design. As shown in Fig. 4, 34 states increased their maximum gross combination weight allowances from 1940 to 1947, while eight lowered them. Nineteen increased the allowable length of combinations, only two decreasing them. The average increase in gross combination weight allowable was 8800 lb, ranging from 4000 to 48,000 lb in the different states. The average increase in allowable length was 6 ft, ranging from 3 to 20 ft.

Improved accessibility for easier maintenance is another trend inspired by economic pressure. More and more ingenuity is being displayed in the design of bulbous enclosures, enveloping truck chassis in the name of styling, to permit access to components for inspection, lubrication, adjustment, and complete unit removal for overhaul.

Interest has been revived in tilting cabs, rollout powerplants, and quick-detachable fenders. Hoods have wider openings, the radiator cap is emerging from hiding, and a maintenance man needs no longer to be a midget to get behind the instrument panel to reach connections. Some of the boards are hinged, others provide access from the front of the dash.

GROWING scarcity of petroleum and the problems of meeting the increasing requirements for diesel fuels raise the question of broadening the fuel specification and improving the appetite of diesel engines for broader ranged fuels.

Starting with a restrictive specification of a base fuel of 50 min cetane number, 0.5% max sulfur, and 150 min flash, the following could be achieved to increase supply for diesel engines:

- If the cetane number were maintained at 50, but the sulfur could be increased to 1% and flash point dropped to 120, a 45% gain in fuel would result, or
- With 150 flash, 0.5% sulfur but with cetane number dropped to 35, an 80% gain in supplies would be achieved, or
- If flash were held at 150 but sulfur raised to 1% and cetane maintained at 35, a 130% increase in supply would be available, or
- Were flash dropped to 120, sulfur of 1% permitted, and cetane number dropped to 35, the increase in diesel fuel supply could be raised as much as 220%.

How many of these restrictive specifications can be relaxed, and to what extent, without decreasing performance and increasing maintenance costs, are questions which present a real challenge to engine designers.

In the long run the diesel engine industry will not dictate the fuel consumed by prime movers as easily as in the past.

Fundamentals of the combustion system must be reviewed if we are to undertake designing engines to burn on heavier and high-sulfur fuels. The diesel engine is a chemical retort maintained at controlled temperature levels, which converts materials in the form of liquid fuel to mechanical energy through a chemical process involving a sequence of closely related events.

This process requires completeness of reaction to avoid deleterious depositions in the combustion chamber. Whether the fuel be heavy petroleum, Fischer Tropse fluid from coal or processed oil shale, the combustion process must resolve the acceptability of the product in terms of low shut down time of the composite earthmoving or other equipment unit investment.

Newer lubricants—functioning as lubricating fluids as well as coolants—have an added responsibility as the blood stream of the engine to purge out of lodgment products which are responsible for engine down time. It has been shown that by maintaining basicity of the oil in the system, wear is cut down to phenomenally low values even when burning high sulfur fuels. This means longevity in the ability to provide returns on the investment.

We pride ourselves on our knowledge to reach 300 and 400 bmep in outputs. But unless these performances are matched by long-lived materials capable of producing such outputs continuously without excessive maintenance, the ultimate gain is lost to the customer.

However, we face a world of broadened concepts and enlarged viewpoints relative to the possibilities of deriving energy from many sources within the realm of the combustion engine scheme.

Future

We view with considerable interest the developments in the hydrogen peroxide method of energy release. The fission of U-235 isotopes has significance in the future of powerplants. We must be cognizant of the possibilities of special fuels such as triptane as a fuel and its utilization in engines of very high output as we know of them today.

In many quarters the gas turbine has been treated as an overall conqueror in the power field. We have heard of the "shoe box" gas turbine and if we believe the newspapers we can almost expect to see motor cars and tractors tomorrow propelled by the gas turbine. Some engineers have acclaimed the early death of the piston and connecting rod, and in several government agencies no new funds are being appropriated for reciprocating engine study.

There are still unexplored possibilities in the use of very high temperature reactions in combustion chambers of reciprocating engines using surrounding metals of relatively low cost. We must curtail the hysteria for tearing up all of the old blueprints. We need caution against going overboard for entirely new power generating methods replacing immediately all the older schemes without checking our resources and evaluating our gains in technological evolution.

The future is generally forecast on the basis of present precepts. Our intimate experience has been directed to powerplant units of under 200 bhp.

Today considerable interest is manifest from 200 to 300 hp. At times the heavy earthmoving industry appears intrigued by even 500 hp and more for special applications. Just where this top horsepower figure will go is dependent upon the efficiency of loading of earthmoving equipment.

The present disparagement between horsepower required for loading as against horsepower needed for hauling is a fair measure of efficiency of any composite unit of earthmoving equipment. The closer the loading horsepower approaches the hauling horsepower, the more nearly consistent will earthmoving costs become.

On the average the future may well look to powerplants with maximum ratings from 300 to 500 hp.

Design of such engines involves critical analysis of a number of factors peculiar to earthmoving operations and practices. Here the powerplant is considered as a component of a composite unit of earthmoving machinery—this depending upon the specific operation which may involve a self propelled scraper, a pusher and a proportionate usage of a bulldozer tractor and tamper.

In the large units mentioned this composite unit may involve an investment of $50,000 by the contractor. The powerplant installed in the self propelled scraper must be considered less in the light of

Diesel Engines

EXCERPTS FROM PAPER* BY
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Director of Research
Caterpillar Tractor Co.

its initial cost but more in relation to its ability to maintain uninterrupted performance of the total investment of the composite unit.

Down time of the composite unit for repairs of one engine will add a faster increment to earthmoving costs than would the depreciation of a higher cost powerplant unit giving great reliability and durability.

This is the first and most significant factor in the choice of powerplants for heavy duty earthmoving equipment: reliability and durability. The higher the total investment the more important this factor in relation to the overall economy of operation.

The second significant factor in powerplant selection, is its ability to produce the highest horsepower yield from a barrel of crude at lowest overall cost per cu yd of earth moved.

A number of considerations are involved in this complex statement. It assumes the use of petroleum or its equivalent in hydrocarbon liquid fuel as the source of energy for engines.

Here is the opinion of a prominent refinery executive on the position of petroleum supply and general distribution as a fuel for farms and the construction services:

1. For the near future the two competing petroleum fuels will be diesel fuel and gasoline. Diesel fuel is expected to prove less expensive in cents per gallon to the consumer. For the near future the economics favor the use of diesel fuel because of the high cycle efficiency of that engine.

2. While diesel fuel is now less costly to the consumer than gasoline, it should be realized that the net return to the petroleum industry, at least in the west, is roughly the same for either and the difference in cost of gasoline and diesel fuel to the consumer involves amortization of plant investment for gasoline manufacture.

3. For the more distant future, it would seem that, in view of the developments in petroleum conversion, choice of fuels made from petroleum should relate primarily to the cycle efficiency of the engine itself, with proper economic consideration for differences in initial engine cost and maintenance.

This question of whether gasoline or diesel fuel will be used in our future internal combustion engines is aptly resolved by Prof. Broeze and Stillebroer in the paper given at a recent SAE meeting:

"A trend towards cheap (low cost) engines requiring relatively expensive fuels would ultimately lead to gasoline engines. The very ability of the expensive diesel engines of using a cheap fuel has been its strong point and has led to its present widespread application. . . .

"However, every effort to make it burn heavier fuel without undue troubles and maintenance, even if resulting in a somewhat more expensive engine, will find its reward in a widened application—which is the ultimate aim."

More High Sulfur Stocks

By heavier fuels the authors include the higher sulfur fuels which are becoming more prevalent throughout the world today. According to statistics collected by the American Petroleum Institute, we have the following abstract of the paper High-Sulfur Crude Oils of the United States—Trends and Supply by Smith and Blade:

"In 1946 the total production of high-sulfur crude oils reached a new high, and the ratio of high sulfur crude oils produced to low-sulfur crude oils was also an all-time peak value. However, the relative sulfur contents of the estimated reserves of the country show approximately the same pattern in distribution as do the sulfur contents of crude oils currently produced, which would indicate that, until new fields of considerable magnitude are discovered, the ratio of high-sulfur to low-sulfur crude oils should not change materially.

"Most of the major petroleum districts of the country are now producing a greater volume of high-sulfur crude oil than at any previous time in their history, and in most instances this is true whether in terms of millions of barrels produced or as percentage of the nation's total oil. Further, a great deal of the oil having high-sulfur content is in the range above 1% sulfur, and even a good portion of that has more than 2% sulfur."

These statistics lead to a new viewpoint. In the years gone by petroleum products had been almost continuously considered surplus commodities, today supply and demand are in substantial balance.

When all the tanks were bulging with surplus stocks the supplier did not have to worry much about satisfying the customers, but now he is forced to plan his production, refining, transportation and marketing schedule for months in advance. Some 15 years ago it was customary to find in remote earthmoving locations, as many as five different specifications on diesel fuels.

That is no longer possible with today's scarcity. The demand for petroleum products has grown to unprecedented value. In a nine-year period the crude oil sources have increased 75% whereas, the diesel fuel demand has increased 250%.

* Paper "Future Powerplants for Tractors and Road Machinery" was presented at SAE National Tractor & Diesel Engine Meeting, Milwaukee, Sept. 9, 1948. Complete paper on which this article is based is available from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.

Eddies Exaggerate F

BASED ON PAPER* BY

F. R. Caldwell, F. W. Ruegg and L. O. Olsen

National Bureau of Standards

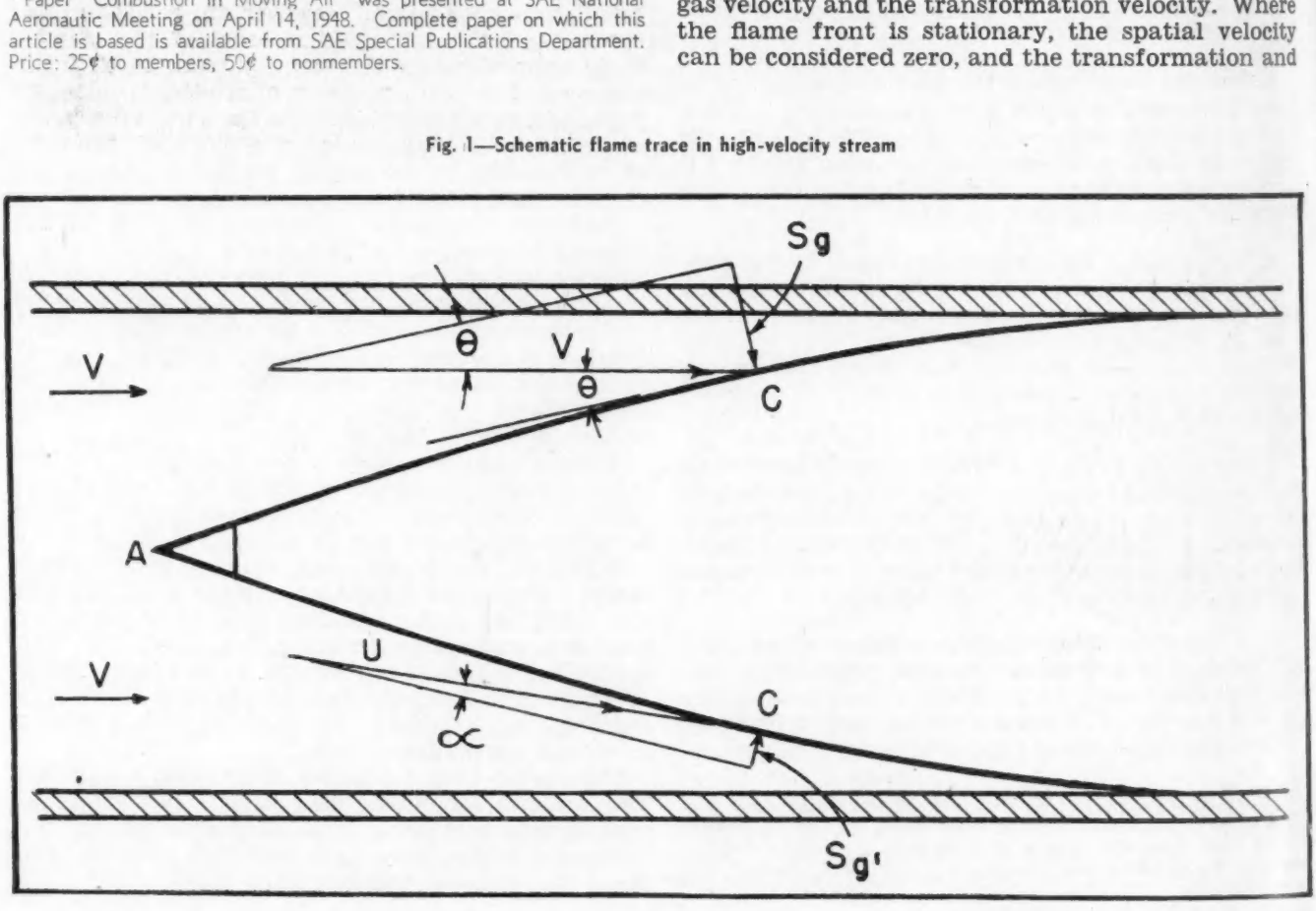
CONSIDERATION of the mechanism of flame propagation in a high-speed stream uncovers a possible explanation of why flame velocities in ramjet burners appear to be of the order of 30 fps although laminar-flow experiments have established them to be only of the order of 1.5 fps. Large-scale eddies seem to be responsible.

* Paper "Combustion in Moving Air" was presented at SAE National Aeronautic Meeting on April 14, 1948. Complete paper on which this article is based is available from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.

Flame velocity, or transformation velocity, is the velocity, S_t, at which flame propagates relative to the unburned gas in a direction normal to the flame front. The velocity at which the flame front moves through space is called the spatial velocity, S_s. The velocity at which the unburned gas moves in space normal to the flame front is called the gas velocity S_g.

The spatial velocity equals the vector sum of the gas velocity and the transformation velocity. Where the flame front is stationary, the spatial velocity can be considered zero, and the transformation and

Fig. 1—Schematic flame trace in high-velocity stream



Flame Velocites

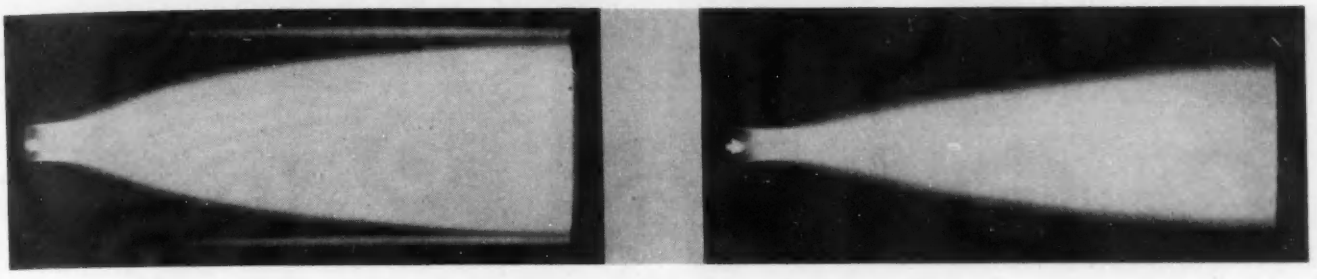


Fig. 2—Photographs of flame traces showing effects of mixture ratio

gas velocities are numerically equal but of opposite direction.

In Fig. 1, let V be the velocity of a homogeneous combustible mixture and A be a flame-holding device or pilot. The combustible gas flowing adjacent to the pilot zone with velocity V is heated to its ignition temperature, and the flame propagates outward into the unburned gas. If the gas is ignited continuously at A, some time later the flame front will have expanded to C and will be defined by the line connecting A and C.

Assuming that the stream lines remain parallel to the axis of the combustion tube, the component of the mixture velocity normal to the flame front, S_g, equals $V\sin\theta$, where θ is the angle between the flame trace at the point considered and the axis of the tube. And flame velocity, S_t, equals S_g but is of opposite direction.

This is the flame velocity that can be calculated from photographs of flame traces, like those in Fig. 2. These two photographs are time exposures of flame traces in the National Bureau of Standards 4-in.-square combustion chamber.

But actually the flame front is not clearly defined over any given small interval of time, as Fig. 3, one frame of a motion picture taken at 1500 frames per sec at M.I.T., shows. Friction between the burned gases flowing at high speed and the slower stream of unburned gases sets up shear forces which cause large-scale eddies at the flame front. These eddies may be of such large scale that they mask the effects of the turbulence in the mixture flowing into the flame front.

The stream lines diverge around the ragged flame front. Referring back to Fig. 1, if U is the velocity along the streamline and α the angle it makes with the flame front, true gas velocity is S_g'. True flame velocity would be numerically equal but of opposite direction.

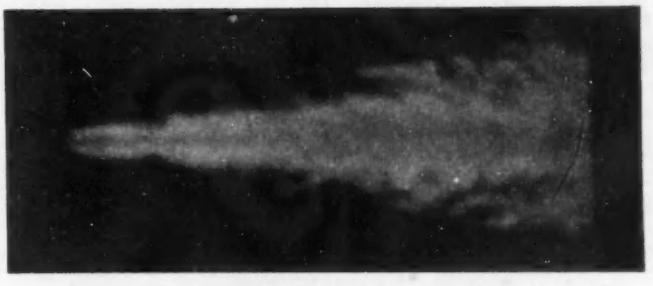


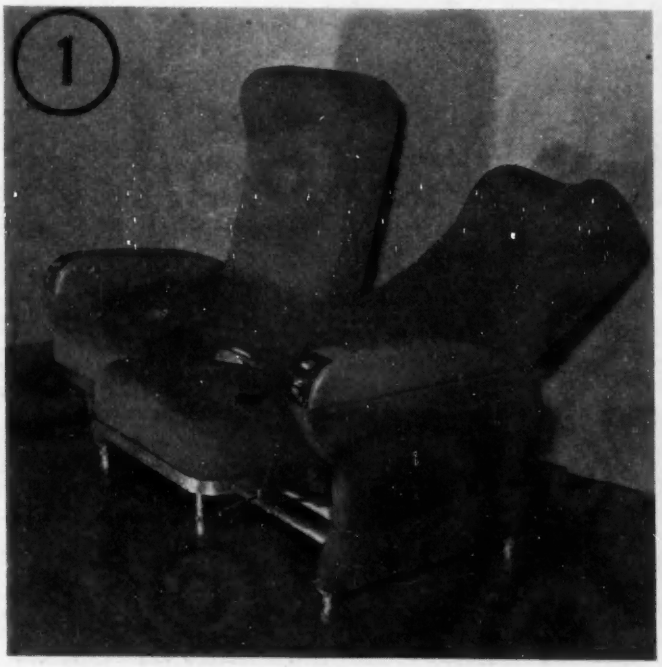
Fig. 3—High-speed motion picture of flame trace, showing eddies

(Evidently flame velocities calculated from time exposures of flame traces are only apparent flame velocities.)

The velocity U and the angle α cannot be evaluated because the eddies continually change conditions in the flame-front neighborhood. Therefore the true flame velocity cannot be evaluated from U and α. But if it could be, true flame velocity values would agree more closely with those measured in laminar-flow experiments than do apparent flame velocities calculated from V and θ.

Apparent flame velocities do, however, serve to compare effects of variables. For example, the two photographs in Fig. 2 show clearly the difference in apparent flame speeds of two different mixtures at the same velocity. The angle θ, and consequently the apparent flame velocity, is greater for the picture on the left. This is to be expected, since transformation velocity for this fuel, propane, is greater on the rich side of stoichiometric.

The effect of the large-scale eddies in increasing apparent flame velocity is decidedly beneficial. Without it, practical application of combustion at high stream velocity might be impossible.







Airliner Seat Arrangement Betters Passenger Comfort

Based on paper by

ROBERT R. HOUSTON
and JOHN M. PARKER

Pan American Airways

THE Sleeperette* arrangement offers an economical solution to the problem of passenger comfort on long-range flights. Sleeperette is a special passenger cabin arrangement incorporating fully reclining seats with adjustable foot-rests and leg-rests, special folding tables, and curtains for compartment privacy. (See accompanying illustrations.)

It gives the passenger greater comfort than do the standard sit-up or sleeper type seats and is more economical for the airline operator because it permits more passengers per airplane; yet it costs less to install and to maintain than conventional-berth sleepers.

From the viewpoint of the passenger, here are the advantages of Sleeperette:

Daytime accommodations are much more luxurious and roomy than those with either the standard or sleeper arrangements. The seat is—and looks—much more comfortable than either of the other two types.

The passenger can stretch out full length at his own convenience at any time of day or night. He may sit up all night, if he so chooses. That convenience is not continuously available on a standard sleeper. For passengers who are not feeling well, wish to sleep or rest, or attend to infants, personal compartment privacy is available with the Sleeperette.

Use of curtains lowers noise level in the cabin; the curtain material absorbs sound. Drafts are less likely to exist and most of the dimmed or undimmed aisle light can be shut off from the passengers.

Sleeperette also makes possible improved food service. Aside from permitting use of linen and conventional tableware, and serving of meals in courses, the adjustable table eliminates knee-balancing of trays. Because of the variety of resting positions and facilities for diversions such as writing and game playing, time passes more quickly in the Sleeperette airplane.

From airline management's side of the fence Sleeperette looks attractive from a cost standpoint. Gains can be pointed out for Sleeperette when compared with original postwar plans for converting DC-4 type airplanes to sleepers with conventional berths.

First, it would have cost $400,000 for 10 sleeper airplanes. The bill for equipping 22 Sleeperettes was $150,000. For night flights, the Sleeperette arrangement increases revenue passenger capacity from 22 to 30. Another big advantage of Sleeperette over berths is that it saves 700 lb of payload per







● What Passengers Can Do with Sleeperette Seating

The passenger finds the Sleeperette seat so comfortable because it provides facilities for rest and recreation. He can sleep, lounge, eat, write, read or play cards in the one seat.

The foam-cushioned seat (1), developed for Sleeperette use, has a moulded headrest, and backrest and a retractable center armrest. The seat can be reclined to any angle from 15 to 65 deg from the vertical (2). The full-stretch legrest is quickly set up by engaging two pegs on the aft end into two receptacles in the front edge of the seat pan; either of two positions may be selected (3). When the seat is reclined, the legrest moves forward with it; since the seat will recline a full 65-deg from the vertical, the effect is to produce a full-length lounge (4).

Main frame of the legrest can be rotated into vertical position and a 14 x 18-in. table made to unfold and to lock both frame and itself into position. Once set up, the table can be rolled fore or aft. The table can be mounted either horizontal or at 4 deg, for eating or reading (5), or for writing (6).

aircraft, estimated to amount to $420,000 per year for 10 airplanes.

Also realized is a saving in time, effort, and supplies; there is no need for handling sheets, extra blankets, ladders, and other paraphernalia required with berths. (Paper "The "Sleeperette"—a New Concept of Comfort for Airline Passengers," was presented at SAE National West Coast Meeting, San Francisco, Aug. 19, 1948. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

* Trademark, Pan American Airways, Inc.

Rocket Fuel Injector Uses Jet Impingement

Based on paper by

ALFRED K. HUSE
Reaction Motors, Inc.

PROPELLANT systems for liquid-propellant rockets are no longer the difficult design problems they used to be, because designers have found relatively simple means of injection and flow control.

They have found that the jet-impingement injector is suitable for any propellants, and that complicated injectors which spin, swirl, or atomize the propellants are unnecessary. Various successful jet-impingement injectors have had impingement angles from 25 to 90 deg. Some injectors have used secondary impingement; for example, streams from one set of holes impinge ¼ in. from the face of the injector, and the resultant stream strikes a similar stream at a point 1½ in. away from the injector.

A piston-and-yoke arrangement operating two pintles is being used commonly as the propellant valve. The pintles are accurately contoured to give

the correct mixture ratio during starting. Other types of valves in use include a solenoid-operated spring-loaded cylindrical piston with a sharp-edged seat and piston-type valves like the familiar intake and exhaust valves.

Propellant valves are usually designed to remain closed except during operation, so that they will close in case of electric power or pressure failure. In test, two or more sets of valves may be used so that propellants can be stopped at points along the feed lines in emergencies. Some test installations introduce water to dilute the propellants that may continue to flow after emergency shutdown.

To start small bipropellant rockets, a starting system has been used which incorporates two small propellant valves as well as the main valves. The small valves open on ignition and allow enough flow to develop 50-100 lb thrust. This pressure opens the main propellant valve controlling the propellant used for cooling. As the coolant flows into the injector, it opens the other main propellant valve. Then propellants from both main valves flow through the injector simultaneously. (Paper "Design and Development of Rocket Engine Powerplants for Aircraft," was presented at SAE National Aeronautic Meeting, New York, April 13, 1948. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Job Needs, Laws Govern Wise Selection of Trucks

Based on paper by

FRED B. LAUTZENHISER
International Harvester Co.

WHAT'S wrong with this picture? Here is a brand new tractor and semitrailer coming down the road, all painted and lettered up in fine style; the trailer probably panelled with shining aluminum or stainless steel—the last word in surface appearance. It has a square end on the trailer body, a 4-ft or greater gap between cab and trailer, with the fifth wheel only about 6 in. ahead of the tractor rear axle.

What's wrong? Plenty. That big gap between cab and trailer might just as well have been closed up by truly round-nose trailer construction. This would increase loading space and eliminate the air pocket that causes tractive resistance.

Net result would be considerably reduced fuel consumption and elimination of much engine wear—the engine would not have to work so hard.

Additionally, by setting the fifth wheel well ahead of the tractor rear axle and by moving the trailer axle fore or aft to its proper location, we transfer a fair portion of the fifth wheel load (at least 10%) to the tractor front axle. This means additional payload—equal to the load transferred to the front axle—can be added. Often this amounts to a ton or more net payload, which resolves itself into an annual increase in net income of $2000 or more per truck.

Most trucks on the road today have something wrong from the standpoint of maximum efficiency. Two basic reasons for this are:

1. No vocational analysis—determining characteristics of the particular operation to which the truck must be tailored.

2. No functional study—finding truck design and combination meeting state rules and restrictions for most efficient operation.

First of the steps to be taken in specifying equipment from the standpoint of what the job needs is to study the operation itself—nature of the commodity, its weight, bulk, quantity to be moved; either per trip, per hour, or per day. Frequency of trips also must be ascertained. This will define the type and size of body.

Needed next is an accurate check as to nature of the roads to be traveled, hills to be climbed, number of starts and stops, with estimated time lost in loading and unloading.

A functional study should follow, a checkup and summary of restrictions on dimensions and weights of various types of equipment imposed by laws of states through which the truck must operate. Often the logical equipment (from the standpoint of lowest cost per hauled or per mile traveled) cannot be operated because of these restrictions.

After a study of potential income versus expense (to forecast profits with the equipment) should follow a check on load distribution. Load distribution, which easily can be calculated, is a case where job requirements must be closely matched with legal restrictions.

For example, some state laws permit additional weight for additional axles under either the four or six-wheel unit or under various types of articulated units; some only for one type or the others; and still a third group permits no additional weight at all. In shuttle operation the tractor and semitrailer really find their important economical use. In such operation one tractor can accommodate from two to five semitrailers, or can transport any one of a large fleet of semitrailers to and from the warehouse.

Because some states generally allow greater overall length for the tractor-semitrailer combination than for straight trucks, this combination provides much greater loading space. This condition is further enhanced where double bottoms are permitted, consisting of the straight truck and full trailer in combination.

No matter what type of equipment selected, proper load distribution pays off in: greater payload, better maneuverability, safer operation, uniform and longer tire life, better balance and longer mechanical life, lower operating cost, and better appearance.

With the static structure determined, next step is to decide what performance is desired in moving the vehicle. One factor to consider is the speed at which you want the load to move up maximum grade to be encountered. In this respect you can't have your cake and also eat it. Regardless of engine output or gear reductions with a given unit, increasing speed sacrifices pulling ability; increasing pulling ability reduces speed.

Mathematical formulas for predicting performance are available from most truck manufacturers.

Translating vocational planning and functional design principles in terms of people, here is what it all boils down to: (1) if the truck does its intended job economically, the owner will buy it; (2) if it performs well, is safe, easy to handle, comfortable, and rides well, the driver will buy it; and (3) if components are accessible and reasonably simple to maintain, and replacement parts are readily available, the mechanic will buy it.

Unless all three buy it, the truck isn't a good proposition for either manufacturer or operator. (Paper "Vocation Selected and Function Planned Motor Trucks," was presented at SAE Northern Calif. Section, San Francisco, May 26, 1948. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.

Design Charts Devised for Stiffened Wing Panels

Based on paper by

NORRIS F. DOW
NACA

(This paper will be printed in full in SAE Quarterly Transactions.)

NACA has tested a sufficient number of flat, longitudinally stiffened compression panels to develop direct-reading design charts giving the most efficient panel proportions to carry a given intensity of loading, over a given effective length of panel, with a given skin thickness.

The charts are intended for airframe designers' use in selecting structurally efficient skin-stiffener panels to carry the compression load resulting from the bending of an airplane wing.

NACA has concentrated on 24S-T aluminum-alloy panels with formed Z-section stiffeners and 24S-T and 75S-T aluminum-alloy panels with extruded Y-section stiffeners. Relative

thicknesses of skin and stiffener range from 0.40 to 1.00; spacing-to-skin thickness ratios range from about 25 to 75; and width-to-thickness ratios for the stiffeners range from about 20 to 60. Very strong riveted connections have been used between skin and stiffeners.

Results of the tests are incorporated in design charts on which the quotient of loading intensity divided by skin thickness appears as a function of the quotient of loading intensity divided by effective length, for various stiffener spacings. (Effective length is panel length times the square root of the coefficient of end fixity as used in the Euler column formula.) Average stress at failing load is also plotted.

For each skin thickness-stiffener thickness ratio for a given material and stiffener shape, six charts are available, each for a particular stiffener height-thickness ratio.

Also included are summary design charts for panels of particular materials and stiffener shapes and tables of cross-sectional area per inch of panel width for various proportions. These charts and tables make it possible to select optimum skin and stiffener proportions and spacing, given such information as loading intensity, effective panel length, and skin thickness.

(Paper "Design Charts for Longitudinally Stiffened Wing Compression Panels," was presented at SAE National Aeronautic and Air Transport Meeting, April 13, 1948. This paper, including charts and tables, is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)



Canadian—Feb. 16

Hotel Royal York, Toronto, Ont., Can.; dinner 7:00 p.m. Vocation Selected and Function Planned Motor Trucks—Fred B. Lautzenhiser, consulting engineer, Motor Truck Division, International Harvester Co., Chicago, Ill. Host: Thompson Products Ltd., St. Catharines, Ont., Can.

Central Illinois—Feb. 21

Hotel Jefferson, Peoria, dinner 6:30 p.m. Meeting 8:00 p.m. Modified Gears—Charles Herr, published a book on gears. Track-Type Tractor in Midwest Agriculture—Carl Kepner. Torsional Vibration Dampers—Robert Sullivan. Practical Application of Electronics—P. J. Costa. Chairman: J. W. Vollentine, mechanical and petroleum engineer.

Chicago—Feb. 8

Hotel Knickerbocker; dinner 6:45 p.m. Meeting 8:00 p.m. Trends in Industrial Power Equipment—H. T. Reishus, general manager, Industrial Power Division, International Harvester Co. Social Half-hour 6:15 to 6:45 p.m. (Sponsored by: Chicago Rawhide Mfg. Co., The Cleveland Graphite Bronze Co. and Imperial Brass Mfg. Co.)

Cincinnati—Feb. 28

Engineering Society of Cincinnati Headquarters Bldg.; dinner 6:30 p.m. Tire Dollars and Sense—J. A. Beckett, field service engineer, General Tire and Rubber Co.

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NATIONAL MEETINGS • 1949

MEETING	DATE	HOTEL
PASSENGER CAR, BODY, and PRODUCTION	March 8-10	Book-Cadillac, Detroit
TRANSPORTATION	March 28-30	Statler, Cleveland
AERONAUTIC and AIR TRANSPORT and AIRCRAFT Engineering Display	April 11-13	New Yorker, New York
SUMMER	June 5-10	French Lick Springs, French Lick, Ind.
WEST COAST	Aug. 15-17	Multnomah, Portland, Oreg.
TRACTOR	Sept. 13-15	Schroeder, Milwaukee, Wis.
AERONAUTIC and AIRCRAFT Engineering Display	Oct. 5-8	Biltmore, Los Angeles
DIESEL ENGINE	Nov. 1-2	Chase, St. Louis, Mo.
FUELS & LUBRICANTS	Nov. 3-4	Chase, St. Louis, Mo.
• 1950		
ANNUAL MEETING and Engineering Display	Jan. 9-13	Book-Cadillac, Detroit

Annual Meeting

Continued from page 21

To improve economy, the advocate of two-stage compression reminded designers of motor vehicle engines that the supercharger can be powered from exhaust energy, according to aircraft practice.

A definite trend toward torque converters for automatic drives in passenger cars was foreseen by a transmission engineer. He based his prediction on the assumption that torque converters will become more efficient. He looks for reductions in flow and shock losses, lower flow constants, and generally better fluids. Even now, the latest torque converters on the market possess satisfactory work-range efficiency and excellent cruising efficiency, he said.

Not all his audience agreed on the superiority of the torque converter. Some disputed the value of the smooth starting claimed for the torque converter, saying that starting and shifting are but a small part of the car's operations. Others said that in its present state of development, the torque converter consumes too much gasoline, contributes to raising engine speeds, and makes for a noisier ride.

New Aircraft Are Cleaner

In the personal-aircraft field, controllable-pitch propellers on newly designed airplanes are making more efficient use of the power available, a review of the field showed. This trend, and a supplementary trend in both newly designed and redesigned prewar models toward reducing drag through generally cleaner aerodynamic design, are leading to far better light-plane performance.

How successful the combination of better propellers and cleaner structures has been is shown by the report given of performance of a late-model airplane in an efficiency contest: The plane was flown 218 miles at an average speed of 115 mph on an average of 3.8 gal per hr, or the equivalent of 30 mpg.

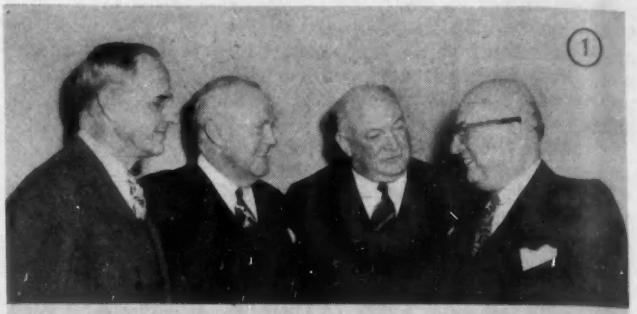
Fabric-covered welded steel tubing for fuselages and fabric covering for wings continues in use, although a few new entrants into the personal aircraft field tried all-metal construction, finding it costly for small production runs. Control surfaces lean toward all-metal construction.

Design trends in arrangement of the rotors that absorb the power in helicopters have not jelled yet because no one arrangement is optimum for all operations. What trend evolves is going to depend largely on the uses to which helicopters are put. The picture now, as a helicopter manufacturer outlined it, shows that various configurations excel in various performance characteristics.

Helicopters with two laterally mounted rotors derive a high rate of climb from their high aspect ratio and low induced drag. This machine may excel for transportation between two towns on opposite sides of a mountain, where it would be climbing much of its airborne time. However, the structure required to support and drive the rotors adds weight and parasite drag.

When the rotors are placed fore and aft, less

Among Speakers' Table Guests







1 (Left to right) H. T. Youngren, vice-president in charge of engineering of Ford Motor Co.; Fred M. Zeder, vice-chairman of the board of Chrysler Corp.; Joseph W. Frazer and Henry J. Kaiser, president and chairman of Kaiser-Frazer Corp., respectively

2 (Left to right) Harold S. Vance, chairman and president of Studebaker Corp.; George T. Christopher, president, Packard Motor Car Co.; and K. T. Keller, president, Chrysler Corp.

3 (Left to right) L. B. Richardson, president, Fairchild Engine & Airplane Corp.; Rear-Admiral T. S. Combs, deputy and assistant chief, Bureau of Aeronautics, Navy Department; and William C. Jordan, president, Curtiss-Wright Corp.

frontal area is required and the structure supporting the rotors can also provide a larger fuselage. Rate of climb is comparatively poor but can be improved by mounting the aft rotor higher than the forward.

For small helicopters, the single main rotor plus tail rotor arrangement is simple, light, and inexpensive. It does require expenditure of extra power in the torque-correcting tail rotor.

Helicopters having centrally located, oppositely turning rotors are particularly efficient in hovering due to the effective vertical displacement of the rotors relative to each other and the recovery of race rotation loss of the upper rotor by the lower rotor. They require no torque-correcting rotor, but the rotor spacing increases parasite drag, raises center of gravity, and complicates storage.

NEW DESIGN FACTS Point Up Economy, Performance Gains

Based on discussions and 20 papers presented at two Passenger Car sessions, two Fuels and Lubricants sessions, two Aircraft Powerplant sessions, one Diesel Engine session, one Engineering Materials session, one Air Transport session, one Body session, one Tractor and Farm Machinery session, one Aircraft session, and one Truck and Bus session. . . . "Universal Joints and Propeller Shafts," by **G. E. Dunn**, Universal Products Co., Inc.; "Factors Affecting Passenger Car Gasoline Economy," by **W. S. James**, Fram Corp.; "Is the Torque Converter Going to be 'It' "?, by **O. K. Kelley**, General Motors Corp.; "Passenger Car Engine Powerplant Mountings," by **E. F. Riesing**, Firestone Industrial Products Co.

"Wide-Cut Diesel Fuels," by **A. B. Crampton**, **S. H. Hulse**, and **N. H. Rickles**, Standard Oil Development Co.; "The Combustion of Diesel Fuel," by **M. A. Elliott**, Bureau of Mines; "Factors Affecting Octane Number Requirement," by **H. J. Gibson**, Ethyl Corp. . . . "Strain Measurements on Rotating Parts," by **R. E. Gorton** and **R. W. Pratt**, Pratt and Whitney Aircraft Division, United Aircraft Corp.; "Boeing 200-Horsepower Gas Turbine," by **S. D. Hage**, Boeing Airplane Co.; "Postwar Reciprocating Engine Development," by **F. J. Wiegand** and **E. H. Olson**, Wright Aeronautical Corp. . . .

"Development of a Combustion Chamber for Medium and High Speed Diesel Engines," by **J. B. Fisher**, Waukesha Motor Co.; "Features of the Sheppard Diesel," by **R. H. Sheppard**, R. H. Sheppard Co., Inc. . . . "Steel Compositions and Specifications From the Consumer's Viewpoint," by **Muir L. Frey**, Allis-Chalmers Mfg. Co.; "Steel Compositions and Specifications From the Producer's Viewpoint," by **C. M. Parker**, American Iron & Steel Institute. . . . "Interior Treatment of Aircraft," by **J. J. Harrington**, Northwest Airlines, Inc.; "How Aircraft Interior Design May Profit by the Experience of Other Forms of Transportation," by **W. D. Teague**, designer. . . . "How Much Advance in New Truck Cabs—A Review of New Cab Designs Now Available," by **C. G. Seashore**, Pennsylvania State College. . . .

"Gear Testing Methods for the Development of Heavy-Duty Gearing," by **R. P. Van Zandt** and **B. W. Kelley**, Caterpillar Tractor Co. . . . "The Design of Aircraft Structures for 'Mass Production'," by **O. A. Wheelon**, Douglas Aircraft Co., Inc. . . . "Means and Objectives in Multi-Ratio Gearing," by **A. M. Wolf**, consulting engineer. . . . **All of these papers will appear in abridged or digest form in forthcoming issues of the SAE Journal, and those approved by Readers Committees will be published in full in SAE Quarterly Transactions.**

WAYS to engineer better economy and performance into ground and air vehicles were beamed at designers via experience and research disclosures. Informative give-and-take among car, truck, aircraft, and diesel engineers—wherever and whenever they met at the week-long meeting—boiled down to specific aims matched with concrete suggestions of how to realize them.

The what-we-want phase of discussions was featured by advice from steel makers and buyers (on how to specify steel) that cut across design specialization boundaries.

Less costly steels to do a better job can be realized by judicious selection and proper ways of specifying steel, metallurgists on the consuming and producing ends agree. Both groups warned engineers to learn more about the steel they order for products they design, in order to reduce material costs without impairing physical functioning of the part.

Objective urged upon all steel users was choice and specification of steel that facilitates the mill's steelmaking job. Putting this philosophy into practice will pay dividends in lower material costs.

Some automotive men disputed the idea that users should leave steelmakers wide latitude in producing steel to perform a specific job.

Car engineers framed *their* objectives around fuel economy, with performance improvements focused on the torque converter, universal joints and propeller shafts, and engine mountings.

The more-miles-per-gallon theme at passenger car sessions pointed up the potent economic weapon car engineers wield in the form of design tools that can boost gasoline mileage.

Import of greater fuel economy with the present national gasoline consumption of 38 billion gallons

At Past-Presidents' Committee Meeting



The SAE Past-Presidents Advisory Committee met during the 1949 Annual Meeting. At the meeting were (left to right) H. T. Woolson, '37; Ralph R. Teetor, '36; C. E. Frudden, '47; J. M. Crawford, '45; R. J. S. Pigott, '48; L. Ray Buckendale, '46; D. G. Roos, '34; A. T. Colwell, '41; J. G. Vincent, '20; A. W. Herrington, '42; C. F. Kettering, '18, and 1949 SAE President Stanwood W. Sparrow

annually was demonstrated by this fact: If every motor vehicle in this country realized a 1% increase in miles per gallon, motorists would get a yearly saving of $90 million, or enjoy an additional 5¾ billion car miles for the same gasoline gallonage.

Getting down to cases, most engineers agreed that use of synthetic rubber in tires has penalized gasoline mileage 5 to 6%. And losses from owners neglecting to maintain proper tire pressure easily may represent a 2 to 3% loss in miles per gallon—possibly over $200 million per year, or 300 miles per year lost by every car and truck in this country.

Dollars Saved by Design

Car engineers learned that if they designed all new cars to deliver 10% more miles per gallon, the saving would be phenomenal. Effect of this economy was illustrated by assuming that the 35 million cars now on the road are replaced with new ones, at the rate of 3½ million per year, and that gasoline costs 24¢ per gal. Our national fuel bill would be reduced 1% the first year, 2% the second, and so on until at the end of 10 years all cars would yield 10% more miles per gallon. Average annual savings during the 10-year transition period, it was estimated, would amount to $450 million, or 9 billion more car miles at 5¢ per car mile.

From broad considerations, car engineering discussions narrowed down to specific improvement of component designs. Much attention was given by designers at the meeting to torque converter improvements aimed at greater efficiency and torque multiplication. The first improvement, it developed, can be achieved by minimized flow friction; the second, by carefully controlling shock losses.

Longer-lived propeller shafts and universal joints proved to be still-attainable goals in the light of pointers from specialists in these areas. Aims set for resilient mountings for car engines were isolation of engine vibrations and torque impulses from the rest of the vehicle, and insulation of the engine mass from incoming vibration excitations—due to road roughness. Yet the device that attaches the powerplant to the frame must be low in cost, all agreed.

Truck and fleet men argued the what-we-want angle in terms of truck cab design needs and multi-ratio gearing objectives.

Both truck makers and operators agreed on the need for improved cab design to enhance safety and comfort of the driver. According to reports of a survey of drivers, fleet operators, safety engineers, insurance companies, and anthropometrical specialists (researchers in human sizing requirements and dimensions), the truck cab today has a long way to go to provide a safe and comfortable living compartment for the driver.

For example, one investigator found seats "pitiful." In checking all types of new trucks, he found some steering arrangements out of balance and one steering wheel almost vertical, producing arm fatigue. In other vehicles he saw seats too far away from accelerator pedals. Lack of an adjustable back in most cases gives rise to discomfort, this investigator reported.

In their search to lower costs, truck design and operating engineers took on the selection of multi-ratio gearing devices. "Shall it be the two-speed axle or auxiliary transmission for minimum investment and operating costs?" they asked.

These are complementary, according to one school of thought. Each fills a particular need. Which to be used, it was shown, depends on the particular truck operation and the degree of economy desired from the additional investment. Others disagreed, contending that the two could be competitive in certain cases.

Seek Basic Diesel Facts

Diesel engineers marked as their aims the desire to learn more about the nature of fuels diesel engines burn, what to do about insuring continued availability of fuel.

Little-known properties of energy-containing molecules in diesel fuels were said to hold the key to more efficient engine designs. A further unraveling of the mysteries of diesel combustion—how these molecules burn—left engine designers with facts physical and chemical to build powerplants better suited to fuels.



A. C. Pilger, Jr., receiving the 1947 Henry M. Horning Memorial Medal from Mrs. Horning, for his paper "Field Testing of Motor Oil and Gasoline," presented before the SAE 1947 Summer Meeting. T. A. Boyd, Horning Memorial Committee chairman, is at the right

Diesel fuel behavior shared the spotlight with fuel availability. Engineers heard that growing demand and increased use of diesel power for railroads pose a long-range threat to availability of diesel fuel for locomotives. To alleviate this situation, diesel railroad operators were advised to switch to wide-cut diesel fuels. Changing over to this type of fuel was said to insure greater volume of fuel with little sacrifice in performance.

Improving Availability

Oil technicians urging this move showed operators that petroleum supply problems hinge on quality and volume. Less restrictive quality makes volume easier to attain. Because this is the route taken by wide-cut diesel fuels, railroad operators were asked to use it to keep diesel fuel flowing from refiner to user.

To improve aircraft economy and performance, aeronautical engineers set as their objective a study of behaviors which their designs must reflect and accommodate . . . behavior of the airline passenger and its influence on aircraft interior design, behaviors of production costs which airplane designs must minimize, vagaries of stresses in rotating parts, and performance of both reciprocating engines and small-packaged gas turbines.

Aircraft designers agreed that efforts must be made to satisfy comfort, aesthetic, and psychological needs of passengers on commercial airliners. Air travel will be made more attractive, it was attested, if passenger health and enjoyment are enhanced.

From possibilities of increased revenues through better interior design aircraft engineers moved to cost-cutting by design in tune with production practicalities. They were urged to apply principles of design producibility to minimize tooling and manufacturing costs.

Discussions showed that airplane design must be in harmony with the plant's production know-how and facilities as well as reflect quantity to be manufactured if manhours, materials, and production time per airplane are to be kept low. Nature of the design was said to affect airplane cost in two ways. First, it establishes minimum or basic cost. Second, it can cause manufacturing disturbances by departing from past practice. With moderate production quantities, this may be many times greater than the basic cost.

Even more elusive than behavior of production costs is that of stresses in rotating parts, particularly those in gas turbines, stress analysts reported. They suggested strain gages to reveal the nature of these dynamic stresses if rotating parts are to be designed soundly.

Strain gages will give the right answers, they said, provided the apparatus is functionally designed and the experimental technique infallible.

And gas turbine specialists viewed the 200-hp Boeing gas turbine as the shaper of new horizons in the field of jet propulsion. They learned that such a "midget" turbine had possibilities in land and sea transportation as well as in the air. Solution of important objectives achieved with this design and clarification of others yet to be solved were seen by some engineers as helpful in launching similar programs.

Despite the rosy future foreseen for gas turbines, piston engine men showed that they are not ready to give up the ghost on reciprocating powerplants. They feel the up-and-down engine still can yield greatly improved performance and life, if engineers step up to the task. And step up to it they should, said several realists, because we will have to live with the reciprocating engine for a long time to come. Much remains to be learned about the piston engine; it is still far from a perfect machine.

Know-How Gained Through Experience and Research

With their aims defined, engineers turned their attention to how-to-do-it. Sessions in all these areas of ground and air engineering were rich with suggested means and methods for achieving both performance and economy goals.

Steel men showed how and why to select and specify properly for economy's sake.

They said that although the number of standard

steels have been reduced materially in recent years, users still are specifying more grades of steel than necessary. Standard steel specifications were shown to overlap widely. Engineers agreed that for precise processing control or for particular engineering requirements, closely controlled materials are essential.

But, some pointed out, if one of a pair of steels being considered is satisfactory, the other one should be also—except in special cases. All that may be required is a minor change in equipment.

In the case of carbon steels, the additional factor of cost enters. The manganese extra breaks at 0.90% manganese.

Some users feel they must have more manganese and are willing to pay for it. Others say they can overcome this need for extra manganese by a happy combination of section size and processing equipment, or are willing to make the changes to get satisfactory performance with the lower manganese range.

Responsibility for problem rests almost entirely with steel consumers, metallurgists said. They can remedy it by making the necessary changes—usually small—to permit use of more common steels. While industrywide producer surveys, it is hoped, will show a trend in use of fewer steel grades, consumers were urged to police their own steel lists.

How engineers order steel also was shown to bear on economics because of the growing tendency to relate price structure—particularly of carbon steels—to steelmaking practice.

Objective of a specification, engineers said, is to get substantially uniform behavior of all materials purchased to it. The old way of controlling this behavior—chemical composition—has reached a point of diminishing returns. Further narrowing chemical limits to get closer control imposes undue operating restrictions on mills. And the method is not and cannot be fully effective. Reason: for heat-treating purposes metallurgists said they need a summation of all factors affecting behavior of steel.

Engineers were told that chemical composition tells little about the steel itself because it does not reveal how the elements are arranged structurally. Because steel microstructure and attendant hardness value correlate well with service performance, the standard end-quench test predicts hardening properties prior to actual use. This test resulted in establishment of hardenability-band specifications for alloy steels.

Hardenability-band specifications, it was claimed, fulfill two objectives. For the user, they provide closer control over behavior than is possible by chemistry alone. For the producer, steelmaking in accordance with H-band specifications is less troublesome to the mills.

The "how" of fuel economy in car design and operation took the form of reports on where to look for savings and on factors influencing engine octane requirements.

Engineers learned that if they could transform, with 100% efficiency, the energy in gasoline to the power that propels the car, greatest possible miles per gallon is 81.5. But since practical transformation of thermal to mechanical energy runs closer to 40%, maximum possible is about 33 mpg.

While driving conditions and habits influence fuel consumption, the car designer has tools at his disposal that can increase miles per gallon.

For example, it was shown that a 0.72 to 1 overdrive—under present road-load conditions—would realize a 13% mpg increase. Reducing the car's weight 15%, so that a smaller engine could be used, stands to gain a 16% saving. Another way of bringing engine size down, by raising compression ratio to 12 to 1, will yield about 30% more miles from a gallon of gasoline.

Continuing on the basis of present road-load conditions, a researcher showed that supercharging the engine can boost gasoline's mileage yield about 17%. And if engineers could design an ideal automatic transmission (to keep the engine operating as closely as possible to conditions of maximum thermal efficiency) they would achieve a 37% gain.

Revelations in octane number economy came from field test reports that showed almost everything the engine meets up with plays a part in determining its antiknock needs . . . atmospheric variables, deposits, fuel and lube types, and hot-spot temperatures.

For example, in evaluating influence of humidity, research engineers found the average effect for 72 cars was a 2.5 octane number reduction for each 50-grain increase in moisture content of the air. And cleaner engines are more sensitive to humidity than those with deposits, it was shown.

Session Chairmen

The 1949 SAE Annual Meeting was planned by the 1948 SAE Meetings Committee and the 12 Professional Activity Meetings Committees.

The 1948 Meetings Committee operated under the general chairmanship of G. A. Delaney and included L. W. Fischer, vice-chairman; W. W. Davies, G. W. Laurie, R. R. Teetor, and the Meetings Chairmen of the 12 Professional Activities.

Chairmen of the 23 technical sessions of the meeting were Carl J. Bock, GMC Truck & Coach Division, Pontiac, Mich.; V. A. Crosby, Climax Molybdenum Co., Detroit; Linn Edsall, Philadelphia Electric Co., Philadelphia; J. W. Greig, Woodall Industries, Inc., Detroit; R. A. Terry, Chrysler Corp., Detroit; J. L. S. Snead, Jr., Consolidated Freightways, Inc., Portland, Ore.; H. B. Knowlton, International Harvester Co., Chicago; Max M. Roensch, Ethyl Corp., Detroit; G. W. Curtis, Timken Roller Bearing Co., Milwaukee; J. B. Armitage, Kearney & Trecker Corp., Milwaukee; C. A. Chayne, Buick Motor Division, GMC, Flint; A. L. Beall, Wright Aeronautical Corp., Wood-Ridge, N. J.; E. H. Smith, Packard Motor Car Co., Detroit; H. D. Hoekstra, Civil Aeronautics Administration, Washington, D. C.; L. A. Blanc, Caterpillar Tractor Co., Peoria, Ill.; G. A. Page, Jr., Curtiss-Wright Corp., Columbus, Ohio; H. L. Moir, Pure Oil Co., Chicago; D. D. Bowe, Aeroproducts Division, GMC, Dayton, Ohio; J. T. Dyment, Trans-Canada Air Lines, Winnipeg, Man.; E. L. Dahlund, Fairbanks, Morse & Co., Beloit, Wis.; L. R. Koepnick, Trans World Airline, Kansas City, Mo.; Prof. E. T. Vincent, University of Michigan, Ann Arbor; and R. D. Kelly, United Air Lines, Inc., Denver.

Deposits were said to make a big difference in engine octane wants. Before-and-after deposit removal tests on 162 cars revealed an average decrease in octane need of 9.4 units after deposit removal. In some cases, it was noted, the decrease was as high as 28.5 units. And along this line no difference was reported in effects of deposits from clear and leaded gasolines.

Emphasis put on ignition timing as a major changer of octane needs struck a responsive note in the fraternity of engine designers. Observations that the effect varied from 0.5 to 1.5 octane units per crankshaft degree (depending somewhat on octane number level) met with general agreement.

In design of torque converters as well as other car components, such as propeller shafts and engine mountings, engineers picked up tips on basic principles that bring results by direct rather than devious routes.

Transmission men heard about how to minimize flow friction and control shock losses to get greater efficiency and torque multiplication from torque converters.

Flow losses are derived from wall friction of vanes and shells, edge loss at vane exit and entrance, bend loss due to circular paths around the core ring, and loading loss due to curvature and change of radius around the vanes. Shock losses are suffered from wrong-angle entrance into the vanes.

Good flow constants in torque converters to achieve high efficiency was said to depend on design of both the path and vanes. Designed torque ratio also influences the flow constant.

To achieve greater torque multiplication, designers were acquainted with the nature of shock losses which stand in the way of this objective. These losses form at the entrances of stator, pump, and turbine.

Ways to improve performance of propeller shafts and universal joints were offered in this four-point check list for designers:

1. The shaft should be accurately mounted on vehicle parts that are stiff enough and have minimum overhang from their supporting bearings.
2. Critical speed of shaft and natural frequency of its supports should be well above maximum speed required.
3. Universal joints should have adequate capacity and do most of their work at an angle of about 3 deg.
4. Character of supports determines critical speed of the shaft. Engineers were cautioned to keep critical shaft speed above the maximum required speed to prevent failure.

Angularity, the third point, influences life of universal joints. Specialists in this work have found that joints should run at high enough angles to circulate the roller bearings. But too high angularity shortens bearing life, experience has demonstrated. Optimum angularity, according to some universal joint engineers, is about 3 deg.

Another designer took issue with this point, noting that the 3-deg angle may be desirable for fixed-angle installations; but in vehicles where the propeller shaft is connected to a flexible mounted axle, the normal spring movement provides sufficient roller circulation.

In finding the most suitable resilient mountings for car engine installations, designers said they first find the axis of minimum moment of inertia. This is the axis about which angular movement or roll of engine mass can be achieved with minimum force. But with the engine firing and delivering torque, a new axis is located—lower in front of the engine than the axis of minimum moment of inertia. This is called the axis of torque oscillation or torque roll axis.

It was shown that if the powerplant is supported in the chassis so that it is allowed to oscillate only about the torque roll axis under influence of firing impulses or torque vibration, the mass then will be excited in only one of the six modes of freedom. And if the natural frequency of the engine mass on the resilient mounting about this axis is low enough to be substantially below the firing frequency at low engine speeds, a good installation will result in so far as torque isolation is concerned. This was said to be a prime requisite of good mounting installations.

These men said that biggest part of resilient mounting cost lies in the metal components to which the elastomer is bonded.

Drive and Driver Concern Truck Men

Commercial vehicle designers and operators took note of what elements go into selecting the proper means of getting multi-ratio gearing and those involved in bettering truck cab design.

Where their reduction ratios overlap, the two-speed axle is more economical in first cost than the auxiliary transmission and can give speedier performance and lower operating cost. The auxiliary transmission was said to be without peer where larger reductions than those provided by the two-speed axle are required, and where three ratios are needed.

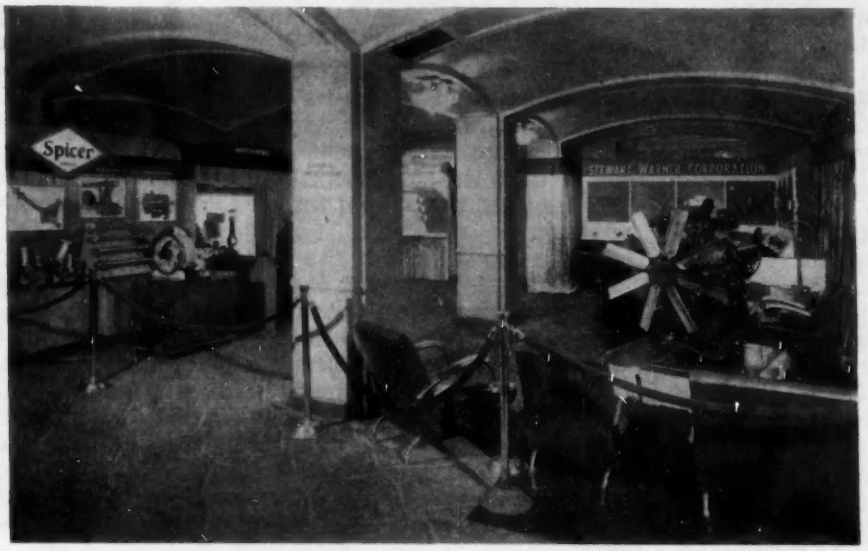
A truck, always fully loaded, will not benefit as much from increasing the number of gear ratios (if transmission and rear axle are properly selected) as a truck with diminishing or oneway loads, traveling over level roads and long grades of varying percentages. A five-speed unit may be an economical means of providing two-speed axle type of operation relative to full load and no load under favorable conditions.

Advantage of a duplex transmission over the two-speed axle for specific situations was exemplified in reports from West Coast operators. Operating 70,000-lb gross train loads over 6 and 8% grades covered with ice and snow demands low enough speeds to get rigs started.

However, the auxiliary transmission weighs more but is all sprung weight, while the two-speed axle's weight is unsprung. Where unsprung weight is important—as in a vehicle traveling over rough terrain—this may show up as a priority consideration. In mountainous terrain, the percent reduction in unsprung weight is of little consequence compared to the other advantages of the auxiliary transmission.

To make cabs safer and more comfortable for the driver, a number of suggestions were made to truck engineers.

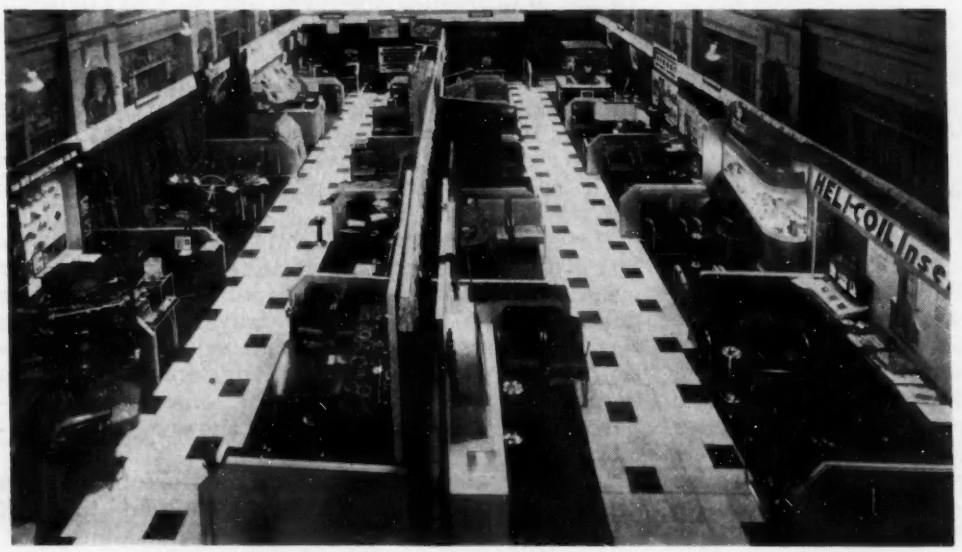
SAE Engineering Display



▲ Part of the 1949 Annual Meeting Engineering Display was staged in the lobby leading into the Italian Garden in the Book-Cadillac Hotel



◀ Testing devices and automotive equipment were also shown in the Reception Room alongside the Grand Ballroom



◀ Largest Section of the 1949 Engineering Display was this in the hotel's Italian Garden

First, they were asked to make it easier for the driver to enter the truck. He should be able to enter from the right side to avoid being struck by oncoming traffic.

Second, adequate protection from fire should be provided.

Third, heating should be considered in the original design with enough heating capacity in the desired directions provided. Safety men said that the theory that heated cabs tend to make the driver sleepy is being discarded.

Fourth, instruments should be easily seen—with a minimum shifting of eyes from the road—both in daytime and at night. Standardization of instrument location is sought.

Mirror facilities, operating controls adhering to principles of motion study, comfortable seats, adequate space, and good visibility also were given consideration in discussions on how to make the cab safer and more comfortable for the driver.

Search Brings Discoveries, Diesel Engineers Are Told

The "hows" to better performance and economy for diesel engineers came from two sources—the research field disclosing fundamental facts and the *fait accomplit* of men who told how they did it in new designs.

Researchers said that diesel combustion experimentation had advanced to the stage where at least a qualitative, if not quantitative, description of the process could be formulated. They said combustion takes place in two stages: (1) the ignition delay stage and (2) the inflammation stage.

During chemical delay, these pryers into molecular behavior found, stepwise oxidation occurs by chain reactions. Rate of these reactions accelerates progressively until ignition or inflammation. Average rate of reaction is increased (ignition delay reduced) by increasing temperature, pressure, or partial pressure of oxygen.

Investigations in the field rather than in the laboratory were the basis of a report from advocates of wide-cut fuels for diesel-powered locomotives. Their tests with 2700-hp diesel locomotives showed wide-cut fuels would impair performance only slightly. Conventional and wide-cut fuels were said to be on a par in deposit-forming tendencies. No appreciable difference was detected in exhaust smoke density.

Tests also showed that wide-cut fuels gave about 1% less power than conventional fuel and that about 2% more of the wide-cut fuel was consumed per horsepower-hour. On a volumetric basis, a 1.9% higher consumption was obtained with the wide-cut diesel fuel. This loss stems from lower heating value and also lower viscosity which results in less fuel delivered per stroke.

Attention turned from diesel fuels to the engines that burned them, with particular interest focused on the Waukesha Mark III and Sheppard engines. Both were claimed to represent advances in economy —fuel economy for the former, maintenance economy for the latter.

Big reason for the Waukesha engine's fuel economy was said to stem from use of a heat-insulating member in the combustion chamber whose temperature increases automatically with increase in speed or load.

This heat-insulated member:

Raises compression temperature above that normally obtained with a given compression pressure, reducing the delay period.

Is self-compensating because its temperature rises with increase in engine speed. Thus it further raises compression temperature and reduces the delay period, allowing fixed injection for the engine's entire speed range.

It serves as a regenerator by restoring to the air—during latter stages of compression—a large portion of the heat it has taken up during combustion and expansion.

It eliminates pungent and acrid smell of exhaust by preventing stabilization of aldehydes (products of partial combustion) against the cooling surface.

It eliminates any cratering or deposition of carbon in the combustion chamber. The heat-insulated member accomplishes this by maintaining the surface, against which the spray might impinge, at a temperature above that at which carbon could adhere.

Outstanding features claimed for the Sheppard diesel are its design simplicity and ruggedness—conducive to economical maintenance.

Small, delicate parts have been kept to a minimum in this engine. Its designer said efforts were made to keep parts as large and as rugged as possible.

From 4000 to 8000 hr of service may be expected of this engine under average conditions without any overhauls, it was said, if proper maintenance is followed.

Burns Variety of Fuels

Its combustion chamber and the fuel injection system can handle any fuel—from kerosene to light crude—with a clean exhaust. And, although not recommended as a steady diet, any common vegetable oil.

New knowledge, new techniques were offered to the aircraft engineering fraternity as ways to inject economy-performance improvements into their designs.

Proponents of airplane interiors suited to passengers revealed that certain design and flying factors create apprehension in passengers at take-off. Roar of the engines and sensation of great speed at take-off accentuate any feelings of fear or insecurity.

All design detail which can reduce these stimuli must be incorporated. Successful sound insulation was said to depend on sealing all cracks and openings in the insulating structure. As much as possible of the airplane structure should get insulation treatment.

While airplane travel was said to present a unique problem in passenger comfort that called for a fresh approach, it was shown that an item or two could be taken from the railroad bag of tricks. Accommodations approaching those of the Century or Broadway Limited would be a welcome relief to a passenger on a 12-hr flight . . . arrangements where he could get up and stretch his legs, go below deck into an entirely different setting and see new faces, and order a drink.

Switching to economics of airplane production,

Aircraft Powerplant Vice-President



Addison M. Rothrock

Addison M. Rothrock, assistant director of aeronautical research of the National Advisory Committee for Aeronautics, Washington, D. C., was elected Jan. 14 by Council a vice-president of the Society representing the Aircraft Powerplant Activity. He takes the place of the late W. J. Blanchard who was elected to this post by the membership. Following his graduation from The Pennsylvania State College in 1925 he remained a year as graduate assistant and then was appointed to the Langley Memorial Aeronautical Laboratory of the NACA. There his early work was research on fuel injection and combustion phenomena in diesel and spark-ignition powerplants. He was put in charge of these projects in 1929. In 1942 he went to the new NACA engine research laboratories at Cleveland where he was in charge of the fuels and lubricants on research and later was named director of research there. He was a member of the Cleveland Section Governing Board, and has served several years on the SAE Aircraft Powerplant Activity Committee. He joined the Society in 1940.

engineers learned that producibility of the design is embodied in these six principles:

1. Understand and design within limitations of the manufacturing set-up.
2. Establish intelligent production breakdown consistent with quantity.
3. Design within limitations the material and equpiment. For example, the aircraft designer should know the production philosophy of 75S aluminum.
4. Design structures and installations that are based on an understanding of the normal manufacturing variations rather than wishful thinking.
5. Adopt a disciplined viewpoint in respect to using established and proved designs—further refined if necessary—rather than completely redesigning for each new model.
6. Explain and pre-plan major changes that are forced by competition.

Issue was taken with respect to the fifth principle, adopting a disciplined viewpoint with respect to established designs. It was contended that the designer should keep an eye toward capitalizing on new techniques and methods. Where a complete new design approach proves that it will pay off, despite the learning and disturbance factors, it should be adopted.

In the airplane powerplant area, the 200-hp Boeing gas turbine was the star attraction. Data revealed about this engine gave engineers important information for further pioneering into small gas turbines.

One big virtue of this particular design was said to be its simplicity—small size and relatively few parts. Without accessories the engine weighs about 150 lb. It is easy to start and develops rated power 15 sec after initial start. The engine accelerates rapidly, going from about 10,000 rpm to full rated speed of 36,000 rpm in 5 sec.

The Boeing gas turbine cannot be stalled, its designers said. While reciprocating engine torque falls to zero at zero speed, this small gas turbine has a stalled torque of twice the rated speed torque.

However, air consumption is very high and intake and exhaust friction losses are excessive. Compressor inlet noises also pose a problem. Silencing this machine was held especially difficult because of the large flow and the need for very low pressure drop. Additionally, idle fuel consumption is very high.

Although production costs are yet unknown, it seemed reasonable to designers of this gas turbine that it will cost less per horsepower than reciprocating engines.

How reciprocating engine refinements are paying off was cited in the case of the Wright C18 engine. Here cooling area was increased by reducing fin thickness and spacing, and also by proportioning fin height around the head to provide maximum cooling at the critical exhaust and port areas of the new forged head.

Durability and reliability of valve gear also were reported improved. To avoid valve sticking, better heat transfer from the exhaust valve was provided in the new forged head by increasing size of the guide boss, increasing valve guide length, and adding more cooling fins in the boss area. Valve seat warpage has been eliminated by the new head which distributes temperature more evenly around the valve seat.

It also was found that with high power ratings and high operating temperatures, strength in the piston's upper ring-belt region becomes marginal. This leads to ring land pounding and ring groove wear. The problem was met in the Wright C18 engine by plating a thin layer of nickel on the ring grooves.

Better techniques were suggested for using strain gages in detecting stresses so that rotating parts, particularly those in gas turbines, could be designed better. Stress analysts emphasized importance of selecting the proper gage.

Two types of wires are now available:

Advance wire, a copper-nickel alloy, is used for

measuring steady state or static strains.

Elinvar is a dynamic strain gage wire which provides a high strain sensitivity. Although quite sensitive to temperature, it was said that this is not objectionable in dynamic strain measurements.

Testing technique discussions carried over to heavy-duty gearing for tractors. Here engineers were concerned with test methods and machines for lab and field testing to help design transmission gears that will "hold up."

Closest approach to field tests in the laboratory was said to be the chassis dynamometer with the whole tractor, except for the track assembly. This set-up is used for such things as an overall check of the power train of a new tractor design for any particular part or parts of the drive. It is claimed to be flexible enough for wheeled vehicles, although it has been used mostly for crawler tractors.

Another test rig described—opposed tractors—involves the whole tractor, but requires much less driving power and a minimum of special equipment. Lab tests also are performed with a pair of transmissions running back-to-back.

Concensus of opinion on lab testing was that it never can completely replace field testing. All that gear designers are aiming for in lab testing is to develop gearing know-how so that designs will be closer to right the first time and take less time for corrections.

Controls, Inspection, Testing Seen Cutting

PRODUCTION COSTS

Based on discussions and four papers presented at one Engineering Materials session, one Aircraft Powerplant and one Aircraft session. . . . "Forging of High Temperature Alloys," by **L. S. Fulton**, Universal Cyclops Steel Corp.; "The Application of Hot Extrusion Methods for Automotive Production," by **C. L. Stevens** and **G. Vennerholm**, Ford Motor Co. . . . "Production Problems of Turbojet Engines," by **T. S. McCrae**, Allison Division, General Motors Corp. . . . "Cost Cutting Chance Laws Can Control Design Tolerances," by **Dorian Shainin**, Hamilton Standard Propeller Division, United Aircraft Corp. . . . **All of these papers will appear in abridged or digest form in forthcoming issues of the SAE Journal, and those approved by Readers Committees will be published in full in SAE Quarterly Transactions.**

THE need for cutting production costs while maintaining or improving performance of the final product points to the increased importance of control in both automobile and aircraft industries, according to the production speakers. This is especially true of jet engine manufacture, the meeting indicated, for here unbelievably high operating temperatures and stresses make the problem particularly difficult. A relatively new type of quality control, which allows the shop to hold dimensional tolerances to closer limits with the same equipment was one means urged toward lowered costs and maintained quality.

It appears that jet materials must be more closely controlled as to chemical composition and physical properties from the raw state to the finished product. Times and temperatures must be held more closely during the processing of materials, it was said, especially when fabricating high-alloy forgings for the "hot" parts of jet engines.

Greater control was also reported as necessary when conventional forging is replaced by hot extrusion for parts particularly adapted to this method.

Inseparably linked with the need for increased control, it was clear, has been the development of more and better inspection and testing methods and equipment, without which, proper control could not be exercised.

Statistical Quality Control

Of interest to both automobile and aircraft engineers was the consideration of statistical methods for controlling dimensional tolerances. It was urged that this relatively new tool be given more widespread application in the industry, for it has already proved itself a tremendous costsaver in many shops —cutting rejects, rework rates, and stepping up production.

Basis of this system is the Shewhart control chart, which is a graphical record of quality that the shop uses to develop tolerances on a lot rather than on each piece.

In the hands of an experienced operator, it was said that such a chart reveals the presence of any variation not inherent in the fabricating process, whether it be caused by man, machine, or material.

By eliminating the cause of the variation, it was explained that the operator can maintain the dimensional range of the part he is making at the spread established by the chance combination of the inherent variables. Obviously, a further reduction of this dispersion is generally impossible unless the basic process is altered to reduce the variables that are characteristic of the operation. This irreducible spread is usually referred to as the "natural tolerance" of the machine.

To develop a Shewhart chart for a particular machine, the range of tolerance of a number of

pieces made by the machine is plotted. It seems that only 30 successive pieces are needed to plot a chart that allows a reasonable estimate to be made of the natural tolerance of the machine.

The author envisioned the typical concern of the future as using control charts to keep vigil over practically every fabricating activity. As a result, he claimed scrap and rework rates would be below 1% and production rates would be in a truly efficient range.

Jet Engine Production Problems

The so-called "hot" part of the jet engine,—the combustion chamber, nozzle diaphragm, turbine, and tailcone—were reported to be responsible for what is probably the most pressing and difficult problem being encountered in the development of jet engines, namely finding materials that possess high enough strength at elevated temperatures.

In so doing, it must be kept in mind that the minimum of critical alloying elements should be selected. It was asserted that some of the materials now being used for certain parts can be replaced by others containing far smaller amounts of such critical elements as cobalt, chromium, nickel, and columbium.

Finding the best way of processing these materials involves:

- Providing maximum structural uniformity throughout forgings. Grain size, in particular, must be kept to a predetermined size by careful control of furnace temperatures. Once the grain gets too large, there appears to be no good way of reducing it again.

- Materials possessing high strength at high temperatures are not readily "pushed around" by mechanical working—making temperature controls of maximum importance to eliminate the danger of burning if the material is too hot and cracking if it is too cold. Many reheats may be necessary to assure proper hot-working.

- Materials must be capable of being hot-worked, welded, and machined without too much difficulty.

The worst problem involved in processing appears to be the elimination of heat distortion, which is affected quite drastically by:

- Actual temperatures to which parts are exposed.

- Temperature differentials in the parts themselves.

Unless the parts have been so annealed or stress relieved as to be essentially free of internal strain, there will be considerable warping and probably even some interferences when working temperatures are reached. This factor, it was emphasized, must be controlled in the manufacturing process.

It was claimed that actually the biggest increases in jet engine service life have come, not from metallurgical contributions in the form of radically new materials, but from changes in engineering design, better processing control, and manufacturing operations. It was admitted, however, that the metallurgists have provided better controls for the manufacture of the alloys being used, and they have suggested fabrication and processing changes that constitute worth-while additions to the jet program.

The troubles the suppliers of these super-duper materials are experiencing were rehearsed by one of their representatives. To give one of his examples:

Whereas previously they had been supplying billets for turbine wheels in the sizes 3-in. rounds to 8½-in. squares, they are now being asked to supply billets of highly alloyed material up to 20-in. squares, with good surface conditions and sound centers being specified, to boot.

He considered that probably the most difficult and most important forging operation is the fabrication of turbine buckets. Only the most highly alloyed materials are used and the blades are shaped so that the actual forging requires innumerable operations. The root sections are either upset or extruded, then they are forged in repeated operations under small hammers. Forging temperatures are lost after two or three blows on most of the materials used, so numerous reheatings are necessary as the operation progresses.

Since these alloys are also especially prone to rupture in the initial forging stages, he said that precautions should be taken at this point to control the reductions necessary for subsequent forging, with close control of temperature being maintained at all times.

After these forgings are fabricated, treated, and machined, he pointed out that they are subjected to magnaflux, zyglo, reflectascope, and x-ray examinations.

He added that ultrasonic testing was also developed to check on whether sound structures are being attained in such parts as turbine wheel forgings, because x-ray investigations were often found to be unsatisfactory.

Special testing equipment for the determination of high-temperature properties has also been developed, it appears, including high-temperature fatigue testing machines.

Use of Hot-Extrusion Method

Another speaker told how the change from conventional forging to hot extrusion for the shaping of a passenger-car front-wheel spindle resulted in such benefits as:

- A saving in the cost of steel amounting to 30%, due to the large saving in weight of material used.

- A saving in capital investment amounting to 20 machines.

- A saving in labor amounting to 65%.

- A saving in floor space amounting to 80%, an undetermined saving in upkeep, together with improved working conditions and a better product.

- Estimated savings in die costs of 40%.

- Increased strength for equal sections, resulting from a near approach to ideal fiber flow conditions.

- An increase in average fatigue life of 17.3%.

The success experienced in this case has encouraged the extension of the method to other parts to which it is particularly adaptable, such as the transmission main shaft gear forging, the rear-axle

driving pinion gear forging, and the rear-axle shaft forging. These shapes were said to lend themselves to extrusion because the largest diameter of the forging permits the use of a punch opening in the die large enough to receive the volume of stock necessary to extrude the shank section and form the flange or gear end.

Extruded forgings differ from conventional forgings, he explained, in that forgings shaped by the drop hammer or conventional press are the result of pounding or squeezing an oversize piece of steel to fit die impressions and flashing out the surplus, whereas the extruded forging is the result of confining the correct volume of heated steel in a specially designed die in which, when the press operates, sufficient pressure is exerted to cause the metal to flow into die cavity, with none left over for flash.

Control of temperature of the steel at the time of extrusion was found to be extremely important. If the temperature is too low, the pressure required is unnecessarily great, whereas too high a temperature may ruin the quality of the steel.

Other work with hot extrusions—admittedly experimental and on a reduced scale—was reported by a discusser to indicate that the savings possible in manpower and capital investment were much smaller than the author had claimed.

In addition, he stated that since there is a distribution of the metal originally in the center of the billet (where most hot-rolled steel defects are concentrated) into the spindle pads, there is introduced the possibility of fracture of these pads, when extrusion is used. In the forged spindle, on the other hand, he said that the center of the original bar is still distributed through the center of the final spindle form, thus keeping any defects in a location where they are supported by surrounding metal.

While admitting that die life was shorter, the author replied that his estimate of saving in die costs is due to the fact that the dies used are smaller and simpler, so that less skill and time are required to sink them for extrusions.

Safety, Cost-Cutting Probed By Truck, Bus, and Airline

OPERATORS

ENGINEERS are putting the squeeze on costs in commercial airline and vehicle fleet operations, meeting participants demonstrated. Truck and bus men accented economies by way of equipment choice—diesel versus gasoline power—and cleaning techniques. Operating economies argued by air engineers were complicated by safety considerations.

Hottest discussions centered about continued search for a nonflammable aircraft hydraulic fluid*. Airline operators want a fluid that won't burn, has many other desirable properties, and doesn't cost much more than presently-used petroleum-base fluids. One that satisfies all three criteria is not yet in sight, chemical researchers agreed.

First thing that both the military and commercial airlines want is a fluid that is fire-proof. It was shown that the search is not an easy one. For example, as resistance to burning of most materials is increased, low-temperature viscosity also goes up—a detriment to low-temperature operation.

As an aid to researchers in this work, SAE has developed an interim specification, known as AMS 3150. Objective of this specification was said to be development of a fluid or series of fluids which could be used in existing aricraft. AMS 3150 compromises on nonflammability and low-temperature viscosity. But the Air Force has not been as lenient as the interim specification on viscosity requirements.

In addition to nonflammability, these requirements were outlined as hydraulic fluid requisities in which little compromise could be tolerated:

1. Effect on Packings—It must not impair functioning of fluid seals, flexible hoses, and accumulator diaphragms if safe and reliable operation of the system is to be maintained.

Based on discussions and seven papers presented at two Transportation and Maintenance sessions, one Aircraft and Air Transport session, and one Air Transport session. . . . "Cleaning of Commercial Vehicles from the Appearance Angle," by **H. H. Earl**, United Parcel Service of New York, Inc.; "Gasoline vs. Diesel Engines For Buses," by **E. N. Hatch**, New York City Transit System; "Gasoline vs. Diesel Engines For Trucks," by **H. L. Willett, Jr.**, The Willett Co. . . . "A Completely Non-Flammable Aircraft Hydraulic Fluid," by **B. B. Farrington, N. W. Furby** and **J. M. Stokely**, California Research Corp.; "Evaluation of Non-Flammable Hydraulic Fluids," by **F. O. Hosterman**, Lockheed Aircraft Corp.; "Development and Testing of Fire-Resistant Hydraulic Fluids," by **D. H. Moreton**, Douglas Aircraft Co., Inc. . . . "Refuelling in Flight," by **C. H. Latimer-Needham**, Flight Refuelling, Ltd. . . . **All of these papers will appear in abridged or digest form in forthcoming issues of the SAE Journal, and those approved by Readers Committees will be published in full in SAE Quarterly Transactions.**

* The complete symposium on Nonflammable Hydraulic Fluids (SP-106) is available for $1.00 to SAE Members ($2.00 to nonmembers) from SAE Special Publications Department. The symposium consists of the three papers and six complete discussions presented at the meeting.

2. Compatibility—The nonflammable fluid and currently-used petroleum fluids must be compatible with each other so that incorrectly or inadvertantly mixing the two will not cause malfunctioning of the system.

3. Toxicity—The fluid must not irritate the skin or develop toxic vapors.

4. Viscosity—The fluid must operate under sub-zero conditions.

5. Specific Gravity—Weight of the fluid must not be excessive to insure safe and reliable operation.

6. Lubrication—The hydraulic pump, valves, cylinders, and fluid motors must be lubricated by the hydraulic fluid since no other source is available.

Investigators who have tried various materials reported that this is how they stack up against these requirements:

Water-base fluids have excellent flammability characteristics under most conditions. But they have one fundamental weakness—the highly-flammable nature of evaporation residue which may result from leakage.

Water-Base Fluid Drawbacks

Although compatible with present rubber seals and components, water-base fluids are limited because of their high viscosities at low temperatures. Lack of lubricity and corrosion of magnesium were claimed to be among their other shortcomings.

Navy men advised that these taken-for-granted limitations of water-base fluids weren't encountered in actual flight experience with the material. They labeled as erroneous the conception that these fluids have high viscosity and low temperatures. Hydrolube U-4 water-base fluids used in F9F airplanes for over a year exhibited no flammability hazards because of evaporation. With only normal makeup fluid being added, water content of the fluid never changed enough during the year to permit lab detection.

The CAA reported similar successful experience with Hydrolube U-4 in a C-54 operated for 300 hr.

Silicone-base materials, most engineers agreed, are relatively flammable—especially when sprayed. They lack lubricating characteristics for steel on steel.

Some felt that while ester-base fluids have good lubricating properties, they are limited in nonflammability and pose a problem of low-temperature viscosity and compatibility with seals. However, one group that recently developed an ester-base fluid claimed it is fire-resistant and adequate from the standpoint of other requirements. This particular fluid also resists aging so that stability and reliability are assured.

Others argued that complete nonflammability is offered by halogenated fluids, one of which has been developed for aircraft hydraulic applications. These fluids were described as fire extinguishers rather than fire promoters. They have acceptable low-temperature viscosity, excellent oiliness, but present a rubber seal problem. Additionally, it was pointed out that halogenated fluids have greater density and must be handled with caution.

Another shot-in-the-arm recommended for air safety was flight refueling. It was argued that about 70% of airline accidents occur during landing and take-off. To illustrate the advantage of flight refueling from this standpoint, the flight from New York to London—via Gander, Newfoundland and Shannon, Ireland—was taken as an example. This trip involves three landings and three take-offs. Refueling in flight cuts this to one landing and one take-off.

This reduces the most prevalent accident hazard to air transportation by two-thirds, said proponents of this technique.

Another gain in safety chalked up for flight refueling is the reduced fuel requirements at initial take-off. All the airplane need carry is enough gasoline to take it to its first tanker station. In case of accident, the lesser amount of fuel reduces the fire hazard.

Chief cost penalty with nonflammable hydraulic fluids, most engineers agreed, is the reduction in payload because of their greater density. According to reports at the meeting, one major airliner estimated the loss of 1 lb of payload for a four-engine airliner might vary from $31 to $154 per year. For this particular airplane, a water-base fluid would decrease payload by 116 lb; a completely halogenated fluid would cost 280 lb.

Assuming an average value per payload pound of $90 and a fleet of 40 airplanes, it was shown that annual revenue loss would run from $418,000 for the water-base fluid and about $1,000,000 for the halogenated type.

Payload penalty due to higher density of these new fluids met with vigorous rebuttal. The revenue loss claim was debated on two points. First, most airplanes, especially those in domestic service, are volume-limited rather than weight-limited. They would be able to carry more payload if it were denser. Thus, makers of this point said, there is a margin of reserve on most air transports to carry denser fluids without suffering a payload penalty.

Second, a flight carrying its full capacity in payload is a rarity rather than the general rule. For this reason, this same group said, you can't blame the denser fluid for depriving the airline operator of so much potential revenue.

Pros and cons on this issue led to general belief that there is no one way of figuring the weight penalty cost. But it did show that there is a tough economic problem facing operators who are aiming to keep airplane weight down.

Engineers sharpened their pencils and added to this bill the increase in cost of the fluid itself. The same airline mentioned has estimated its 1949 hydraulic fluid needs at 22,000 gal. Compared to current petroleum-base fluids, increased fluid cost per year would be as follows: with water-base fluid, $242,000; with completely halogenated fluid, $154,000; and with one of the higher-priced snuffer fluids, perhaps as high as $1,000,000. To this cost must be added that for packings, mechanical changes, and spare parts; they can be high.

However, it was agreed that these additional costs were a small penalty to pay if the fluid change prevented loss of human life. But the job of finding the right fluid, it was emphasized, remains to be completed. And one fluid for both military and civil aviation was visualized as the ideal setup.

In contrast with nonflammable fluids, the flight refueling proposal was rife with opportunities for lowering operating costs.

Economies with flight refueling were said to stem from these three possibilities:

1. Standardization of aircraft design and air fleets for all long-range operations.
2. Ships can be smaller and still complete long nonstop flights.
3. It insures a higher payload factor by reducing the fuel load necessary, particularly at take-off.

A major change seen forced by refueling-in-flight is the obsolescence of giant airliners for North Atlantic and other long-range flights. In fact, it was claimed that the flight-refueled airplane can be between one-half and one-third the size of one designed to take off with sufficient fuel for a 5000-mile flight.

Economies from size reduction alone were said to accrue in the form of lowered insurance, fuel and oil, and maintenance costs—all roughly proportional to airplane size. Additionally, length and strength of runways are dictated by aircraft size and weight so that savings in airport construction also could be realized.

Other cost-reducing advantages were seen for flight refueling over ground refueling . . . saving in time, less wear and tear on the airplane by eliminating landings and take-offs, reduced airport congestion (an important advantage to any metropolitan airport), greater use of airplane and crew, and less inconvenience to passengers.

The New York-to-London route was pointed to again as a specific case where flight refueling could achieve these advantages.

The refueling stops at Shannon and Gander could be eliminated. (Small traffic potential at these points can be handled by domestic service, it was said.) Using these locations as tanker stations—near which airplane tankers could refuel airliners in flight—would permit the through airplane to take off at light weight; yet the airplane could carry more payload under the new plan than under the old, where it had to carry enough fuel for the Shannon-to-Gander run at take-off.

Vehicle Men Study Evaluation Methods

Money-saving talk among truck and bus operators centered about the much-discussed but never-settled problem of diesel versus gasoline engines for trucks and buses. Answer to which is more economical that came out of the meeting is: It depends . . . it depends on the particular operation. And to get a true comparison, said engineers who have studied the situation, the operator must use a realistic method for making the determination.

Crux of the proper method of comparing the economics of gasoline and diesel engines, fleet operators learned, is to compare like things—apples with apples, not oranges with peaches.

Select the right samples, was the first word of advice . . . only cost records of those trucks or buses truly comparable, vehicles which carry the same load over the same terrain, and only the same fairly short calendar period for all vehicles involved. This was shown to eliminate the pitfalls of the "historical" method, wherein unlike things are laid side-by-side.

Other items which should be rectified to get a realistic picture are age of vehicle, cost variation due to fluctuating mileage per month, and quality of manufacture. After the sample sorting, next step given was the data gathering. Facts should be found on both cost per mile and miles per month. Recommended for consideration were variable costs such as fuel, preventive maintenance, grease, oil, parts and labor, shop overhead, and washing.

Most obvious place to look for cost differentials, it developed, is in initial price and the fuel bill.

To prove this point, records of a New York City bus fleet were revealed. Average price of replacement engines for buses of this fleet are: $2024 for gasoline engines and $3303 for diesels; the gasoline engine costs about $1279 less. But this difference is more than made up in this fleet by the savings in fuel bills with diesel engines. For buses running 45,000 miles per year in this particular operation, the annual saving in fuel cost with the diesel engine is about $270 annually.

In comparing other cost aspects of fleet operation, it was shown that maintenance expense is about the same for both types of engines. But the diesel requires more careful preventive maintenance than the gasoline engine. This calls for properly trained mechanics.

For this reason, it was said that small fleets might do better with gasoline engines. Since good diesel mechanics generally are not for hire and must be trained, the operator with few vehicles, who generally does not have training facilities, will have a maintenance headache on his hands.

Fleet operators also heard about vehicle cleaning costs from reports of fleets running various types of vehicles, using different kinds of cleaning methods and equipment.

For example, for trucks the figure ranged from $20 per year for wages and $3.25 for soap to $62 for wages and $7.50 for cleaner. Bus cleaning costs quoted varied from an annual washing expense per bus of $107 for wages and $7.50 for soap to as much as $200 for labor and $5.00 for soap.

Factors determining cleaning expense were shown to be the kind of dirt to be removed, cleaners applied, and equipment used.

Dirt falls into two classes—dry and sticky. Dry material, such as dust and fly ash, many operators find, can be removed with an ordinary cold-water wash. They require no chemicals.

Sticky materials—which include oils, finely-powdered rubber, and dried-up bugs—pose highly chemical problems which must be met with chemical cleaners. Soaps, synthetic detergents, inorganic salts, solvents and acids were cited as cleaners of this type, each suited for a specific kind of job, each a compromise between economy and safety of the painted surface for that job.

Investment in washing equipment was shown to run the gamut from hand brushes and chamois cloths to nozzle-equiped spray booths, with the degree of mechanization depending on fleet size.

Vehicle cleaning discussions evinced so much enthusiasm for more facts on the subject that an SAE committee, set up to probe the need for such data, probably will undertake as a specific project the working up of information leading to more efficient vehicle cleaning.

PASSENGER CAR, BODY

Book-Cadillac Hotel
Detroit, Mich.

E. N. Cole
General Chairman

TUESDAY, MARCH 8

9:30 a.m.

D. G. ROOS, Chairman

Trends in European Car Design
—A. C. SAMPIETRO, D. R. Robertson Ltd., and R. A. RAILTON, Consulting Engineer

(Sponsored by Passenger Car Activity)

2:00 p.m.

K. E. COPPOCK, Chairman

Automotive Seating—Symposium

Frames—J. E. BRENNAN, Chrysler Corp.

Springs—W. A. CLARK, L. A. Young Co.

Padding Materials—J. C. GORDON, Allen Industries

Trim—C. H. GRAHAM, General Motors Corp.

(Sponsored by Body Activity)

8:00 p.m.

R. J. WATERBURY, Chairman

Technical Highlights of Postwar Autobiles
—A. M. WOLF, Consulting Engineer

(Sponsored by Body Activity)

WEDNESDAY, MARCH 9
PRODUCTION CLINIC

10:00 a.m. to 12 noon — 2:00 p.m. to 4:00 p.m.

JOSEPH GESCHELIN, Chairman

Eight separate informal gatherings to exchange information and experience on vital production problems. Each will be sparked by a panel of experts as follows:

1. MATERIALS HANDLING

O. E. JOHNSON, Kaiser-Frazer Corp., Panel Leader

Panel Members: R. K. DEGENER, Equipment Manufacturing, Inc., W. J. DERNBERGER, Ford Motor Co., O. A. PARMENTER, Factory Sales and Service Co., R. R. SHELTON, Mechanical Handling Systems, Inc., E. B. THURSTON, Haughton Elevator Co., C. P. WHITELEY, Automatic Transportation Co.

(Sponsored by Production Activity)

2. PRODUCTION AND MANUFACTURING CONTROL

E. F. GIBIAN, Thompson Products, Inc., Panel Leader

Panel Members: J. E. ADAMS, White Motor Co., F. E. BOZE, Delco-Remy Div., General Motors Corp., C. A. KOEPKE, Consultant, P. A. MILLER, Leece-Neville Co., G. S. WILCOX, Plymouth Div., Chrysler Corp.

(Sponsored by Production Activity)

3. GEAR DESIGN AND PRODUCTION

R. P. LEWIS, Spicer Manufacturing Div., Dana Corp., Panel Leader

Panel Members: B. F. BREGI, National Broach and Machine Co., BAIN GRIFFITH, Chevrolet-Gear and Axle Div., General Motors Corp., F. E. McMULLEN, Gleason Works, G. H. SANBORN, The Fellows Gear Shaper Co., D. T. SICKLESTEEL, Detroit Gear Div., Borg-Warner Corp., JOHN WETZEL, Dodge Div., Chrysler Corp.

(Sponsored by Production Activity)

4. PREVENTIVE MAINTENANCE OF PLANT EQUIPMENT

H. R. BOYER, General Motors Corp., Panel Leader

Panel Members: H. E. HARDENBROOK, Buick Motor Div., General Motors Corp., W. C. HARTLEY, Nash-Kelvinator Corp., H. C. KELLOGG, Ford Motor Co., OTTO KLAUSMEYER, Studebaker Corp., H. S. WELLS, Chrysler Corp.

(Sponsored by Production Activity)

& PRODUCTION MEETING

March 8-10

5. INSPECTION AND QUALITY CONTROL

A. A. WEIDMAN, Detroit Diesel Engine Div., General Motors Corp., Panel Leader

Panel Members: J. N. BERRETTONI, Dr. J. N. Berrettoni and Associates, R. H. COLVIN, Burd Piston Ring Co., G. K. PEETS, Packard Motor Car Co., JAMES RAYER, Timken-Detroit Axle Co., S. C. STARNAMAN, Oldsmobile Div., General Motors Corp., KEITH VAN KIRK, Magnaflux Corp.

(Sponsored by Production Activity)

6. SURFACE FINISH

C. R. LEWIS, Chrysler Corp., Panel Leader

Panel Members: E. J. ABBOTT, Physicists Research Co., H. J. GRIFFING, Norton Co., F. R. McFARLAND, Packard Motor Car Co., C. L. STEVENS, Ford Motor Co., R. P. TROWBRIDGE, Research Laboratories Division, GMC

(Sponsored by Technical Committee on Surface Finish)

7. RECENT DEVELOPMENTS IN HEAT TREATING PROCESSES

10:00 a.m. to 12 noon

R. G. McELWEE, Vanadium Corp. of America, Panel Leader

PAPERS

Salt Bath Heat Treatments as Applied to Automotive Parts
—L. B. ROSSEAU, Ajax Electric Co.

Induction Heating for Forging and Heat Treatment
—A. W. HERBENAR, Ohio Crankshaft Co.

Atmospheres for Heat Treating Automotive Parts
—O. E. CULLEN, Surface Combustion Co.

Present Status of Heat Treatment as Applied to Cast Iron
—C. F. JOSEPH, Central Foundry Div., General Motors Corp.

Panel Members: HAROLD BATES, Fairfield Manufacturing Co., E. H. STILWILL, Dodge Div., Chrysler Corp., E. D. WIARD, Gorham Tool Co.

(Sponsored by Engineering Materials Activity)

8. BODY STEEL AND ITS TREATMENT

2:00 p.m. to 4:00 p.m.

H. C. SMITH, Great Lakes Steel Corp., Panel Leader

PAPERS

Quality in Drawing Steel
—C. A. BURKHALTER, Wheeling Steel Corp.

Steel Forming and Drawing
—C. L. ALTENBURGER, Great Lakes Steel Corp.

Chemical Surface Treatments to Aid Drawing
—V. M. DARSEY, Parker Rust Proof Co.

Welding as Applied to Body and Frame Construction
—J. F. RANDALL, Ford Motor Co.

Panel Members: T. F. OLT, Armco Steel Co., N. E. ROTHENTHALER, Ford Motor Co.

(Sponsored by Engineering Materials Activity)

Wednesday Evening

8:00 p.m.

E. S. MacPHERSON, Chairman

Frame versus Frameless Cars—Symposium

Design of Frameless Car Body Structure and Its Relation to Service
—THEODORE ULRICH, Nash Motor Div., Nash Kelvinator Corp.

The Frame and Body Combination
—D. W. SHERMAN, A. O. Smith Corp.

The Advantages of the Unit-Type Construction in Automobile Bodies
—A. R. LINDSAY, Budd Co.

(Sponsored by Passenger Car Activity)

THURSDAY, MARCH 10

9:30 a.m.

W. S. JAMES, Chairman

Elements of Car Performance—Symposium

New Ways of Measuring Vehicle Performance on the Road
—W. A. McCONNELL, Ford Motor Co.

Thermal Efficiency and Mechanical Losses of Automotive Engines
—M. M. ROENSCH, Ethyl Corp.

Passenger Car Wind and Rolling Resistance
—K. A. STONEX, General Motors Proving Ground

A Versatile Car Testing Dynamometer
—NEIL MacCOULL, Texas Co.

(Sponsored by Passenger Car Activity)

2:00 p.m.

F. F. KISHLINE, Chairman

The New Cadillac Engine
—H. F. BARR and E. N. COLE, Cadillac Motor Car Div., General Motors Corp.

Air-Cooled Engine Possibilities for Passenger Cars
—C. F. BACHLE, Continental Aviation and Engineering Corp.

(Sponsored by Passenger Car Activity)

DINNER

6:30 p.m.

E. P. LAMB,
Chairman, SAE Detroit Section

S. W. SPARROW,
SAE President

GEORGE W. ROMNEY,
Toastmaster

"STEEL WILL COME THROUGH"
EARL L. SHANER, President and Treasurer
The Penton Publishing Co.

About



HAROLD E. CHURCHILL has been appointed director of research in the Engineering Division of Studebaker Corp. He joined the company in 1926 as an assistant laboratory engineer. Churchill is chairman of the SAE Chicago Section and is a member of several SAE technical committees. He has also presented a number of papers before national meetings.



G. WAINE THOMAS was recently promoted to chief engineer of the Automotive, Truck and Industrial Engine Division of Continental Motors Corp. Before joining this company in 1942, he was connected with the Mack Co., and prior to that held a similar position with Reo Motor Car Co. Last year, Thomas was chairman of the SAE Western Michigan Section.



ARTHUR M. SWIGERT has been appointed vice-president in charge of all manufacturing operations of Universal Products Co., Inc. in Dearborn, Mich. Swigert, who joined Universal earlier this year, had for many years been associated with Chrysler Corp. in various capacities.



JOSEPH S. HARRIS, left, formerly assistant manager of Shell Oil's Aviation Department in New York City, has been appointed head of the department to succeed **DR. R. T. GOODWIN**. Goodwin has been named manager of Shell's Special Products Department. Harris has been with Shell since 1930, when he started with the firm as a research man in the Technical Products Department. He has been assistant manager of the Aviation Department since 1942.

GERALD C. DUNBAR is now superintendent of transportation and maintenance for the Arabian American Oil Co. in Dhahran, Saudi-Arabia.

ROBERT W. CARR was recently promoted to the special products representative for the San Francisco Division of Shell Oil Co. which takes in all of the western half of Northern California.

RICHARD J. McCAFFERTY has now become design engineer for Douglas Aircraft Co. in Long Beach, Calif. His previous connection was with Lochmoor Mfg. Co. in Detroit.

ALVIN H. BAUMAN, JR., is now engineering trainee at the Kaiser Frazer Detroit Engine Division.

HOWARD IRA MINSON is co-owner of the Automotive & Industrial Machine shop in Richmond, Va. His previous company connection was with Motor Parts Corp., where he was superintendent.

GEORGE S. CASE, chairman of the board, Lamson & Sessions Co., and **FRANK P. TISCH**, chief engineer, Phoell Mfg. Co., were speakers at the Dec. 16 meeting of the American Institute of Bolt, Nut and Rivet Manufacturers at which the new Uniform Screw Thread Standards were discussed. Both are members of the SAE Screw Threads Committee.

WILLIAM M. KAUFFMANN recently became engineer in charge of research and development for the Worthington Pump & Machinery Corp., Buffalo, N. Y.

JOHN C. KEPLINGER, vice-president in charge of sales of Hercules Motors Corp., Canton, Ohio, was recently promoted to executive vice-president of the company. Keplinger has been associated with Hercules since 1926 and has served as a member of the sales staff, as sales manager and as vice-president in charge of sales. He will continue to direct the sales activities of the company.

SIDNEY S. HATCH has left the Commonwealth and Southern Corp. to accept the position of chief test engineer at the AC Spark Plug Co. in Milwaukee, Wis.

HUGH MATTHEW SMALL is now automobile mechanic at the Earl Marks Co. in Portland, Oreg.

WILLIAM S. POWELL has become a consulting engineer. He will be located in Windsor, Ontario, Canada.

J. F. WINCHESTER of New York City, recently received a Certificate of Appreciation from the American Petroleum Institute in Chicago. It is in appreciation of the services he rendered as a member and as chairman of the Central Committee on Automotive Transportation.

ROBERT L. DOUGLAS is now connected with the California Truck Rental Co. in Los Angeles. He was formerly employed with Chester Mack Sales and Service, Inc., as service manager.

ROBERT A. HEATH is now with T. W. Moss & Associates, manufacturers agents for Wilkening Mfg. Co., makers of Pedrick piston rings. His work is sales engineering. He has resigned as senior project engineer from Oldsmobile.

EDWARD LUPTON PAGE was recently appointed instructor in the Department of Mechanical Engineering at the University of Michigan, Ann Arbor, Mich.

GILBERT L. ROTH has become affiliated with Northrop Aircraft, Inc. in Hawthorne, Calif. Previously he was a junior mechanical engineer for Fairchild Engine & Airplane Corp., NEPA Division, Oak Ridge, Tenn.

STANLEY B. TUTTLE, now design engineer for Hughes Aircraft Co., Culver City, Calif., had been associated with K. C. Diesel Power Co. in Kansas City, Mo.

Members

WILLIAM L. STEINWACHS, now an aerodynamicist with North American Aviation, Inc. in Los Angeles, previously held a similar position with Curtiss-Wright Corp., Airplane Division in Columbus, Ohio.

SAMUEL L. SOLA is now design engineer on mechanical products for the Rhodes-Lewis Co. in Los Angeles.

ROY S. GODBEY has become manager of the Sales Engineering Division of the Ashland Oil & Refining Co. in Ashland, Ky. His former post was in the Dynamometer Division of the Electric Products Co. in Cleveland, Ohio.

GORDON DAVISSON has recently joined the staff of Young Radiator Co. in Racine, Wis., as an engineering representative. After a short on-the-job training course to familiarize himself with all phases of the manufacture and engineering of Young Products, Davisson will devote his time primarily to field work and the service of Young customers.

HENRY LOWE BROWNBACK has received the Chevalier of the Legion of Honor from the President of France.

D. H. MIKKELSON, formerly superintendent of automotive equipment for the Honolulu Rapid Transit Co., has been named superintendent of equipment for that company. This promotion adds 115 trolley buses and a body shop to his former responsibilities. Mikkelson was chairman of the SAE Hawaii Section in 1947.



BURKHALTER



PEARCE

R. R. BURKHALTER has been appointed chief engineer of the Universal Joint Division of Spicer Mfg. Division of Dana Corp. He succeeds J. W. B. PEARCE, who retired after more than 43 years of service with the company. Pearce has been an SAE member since 1914. Burkhalter has been with Spicer for 20 years. He has been active in SAE work and at present is serving on the SAE Parts and Fittings Technical Committee

WILLIAM T. THOMSON, associate professor of mechanics at the University of Wisconsin, recently published a book titled "Mechanical Vibrations." Designed to present the fundamentals of vibration theory, the book emphasizes rational analysis developed from basic fundamentals. It includes a discussion on vibration of elastic bodies. Electromechanical analogy and the similarity principle are offered as a practical approach to evaluation of behavior of mechanical systems by experimental means.

WILLIAM T. BEAN, JR., formerly project engineer in charge of the experimental stress analysis laboratory of the Continental Aviation and Engineering Corp., announces a consulting service in product design and development. His office is located at 5005 Parker Ave., Detroit, Mich.

JAMES E. P. SULLIVAN has been appointed by the Dayton, Ohio, City Commission to serve a five-year term on the Dayton City Plan Board. He is a laboratory engineer for Chrysler Airtemp. Sullivan is field editor for the SAE Detroit Section.

EVERITT CARTER has become a sales engineer with Faber Laboratories in San Francisco. Prior to this post he was fuel and lubricating engineer at Standard Oil of California, same city.

GLEN E. McPHERREN has become design engineer at the Consolidated Vultee Aircraft Corp. in San Diego, Calif.

COL. JESSE G. VINCENT, Packard director and vice-president was re-elected president of the Automobile Club of Michigan at the annual board of directors' meeting in Detroit. Vincent is a past-president of SAE.

ALLEN W. MORTON is now consultant for the Liberia Co. in New York City. His former connection was with Koppers Co., Inc. in Baltimore, Md.

A. R. FORS recently resigned his position with the Airtemp Division of Chrysler Corp., Dayton, Ohio. He is now industrial consultant for J. C. Chambers & Associates in Los Angeles.

W. R. ZALESKI is now automotive engineer, U. S. Army Ordnance, Automotive Division, Transport Vehicle Branch in Aberdeen, Md. Prior to this he was an engineer at Bendix Aviation Corp., South Bend, Ind.

LEONARD ROSE is now a junior mechanical engineer with the Boeing Aircraft Co. in Seattle, Wash.

WALTER W. KOVALICK recently became a plant engineer for the Ingersoll Steel Division of the Borg-Warner Corp., located in Chicago. He previously held a similar position with the Firestone Tire & Rubber Co. in Akron, Ohio.

HAL ARNOLD LIVINGSTONE has been appointed vice-president of the Bailey Motor & Equipment Co. in Ocala, Fla., after having served as service engineer for the Pontiac Motor Division in Pontiac, Mich.

L. A. McDONELL has become an automotive engineer with American Tractors, Ltd. in Honolulu, Hawaii. McDonell is one of the original organizers of the SAE Hawaii Section and was chairman of the Section in 1945.



RAYMOND A. SYNDER was recently appointed to the position of sales manager of the Original Equipment Piston Ring Division of Sealed Power Corp., Muskegon, Mich. He has been with Sealed Power for 24 years, and was formerly assistant chief engineer. Prior to entering the Engineering Department, he spent several years on manufacturing and production problems.



SELDEN T. WILLIAMS, vice-president of Scovill Mfg. Co., Inc., was appointed general manager of A. Schrader's Son Division of that company. He joined A. Schrader's Son in 1929 and in 1944 was appointed vice-president of Scovill Mfg. Co., Inc., in charge of manufacturing of Schrader domestic and foreign plants.



CHARLES RIDLEY, until recently research engineer of Ford Motor Co. Ltd., Dagenham, Essex, England, has formed Ridley-Industrial Ltd., Kenilworth, Warwickshire. The company has developed a small electric car, hydraulic pumps, engines, and other automotive equipment. He is a former director of Triumph Co., and has had engineering experience with Heinrich Lanz, Daimler, Citroen, and Riley.

THEODORE P. WRIGHT, former administrator of the Civil Aeronautics Administration and vice-president of research of Cornell University, has been elected to the board of directors of Robinson Airlines. Robinson Airlines links New York State's southern cities of Ithaca, Elmira, Binghamton, Endicott and Johnson City with New York, Northern New Jersey, Albany, Rochester, Buffalo and Niagara Falls. Wright was appointed Cornell vice-president for research and president of the Cornell Research Foundation and the Cornell Aeronautical Laboratory at Buffalo, N. Y., early this year.

WILLIAM A. M. BURDEN has been elected president of the Institute of the Aeronautical Sciences to succeed **JOHN K. NORTHROP.** In 1947 Burden resigned as assistant secretary of Commerce for Air after serving in that and similar Government posts through the war. He is now a specialist in aviation with Smith, Barney & Co., stock brokers.

HARRY R. GREENLEE is now staff engineer with the Chassis Division of the Chrysler Corp. in Detroit.

A. P. (JACK) FONTAINE, director of the University of Michigan's Aeronautical Research Center at the Willow Run Airport, has been appointed a member of the Technical Evaluation Group of the Research and Development Board's Guided Missile Committee. As a member of this group, he will assist in evaluating the accomplishments of all university, government and industrial contracts covering guided missile research and development in this country.

JOSEPH R. SHEWITZ has become fire control specialist (electronics) for Consolidated Vultee Aircraft Corp. in Fort Worth, Tex.

EUGENE C. PEREIRA and HENRY MARTIN GRABARZ recently joined Slick Airways, Inc., San Antonio, Tex.

JOHN E. LOUGH, who recently graduated from the University of Wisconsin, is assistant engineer for the Public Service Co. of Colorado in Denver.

LAWRENCE J. MacDONALD is now an engineering draftsman for Consolidated Vultee Aircraft Corp. in Fort Worth, Tex.

W. S. MELLO was recently chosen "man-of-the-week" by the Honolulu Chamber of Commerce in its campaign to illustrate the rise of men by their own efforts to positions of trust and responsibility. Mello was obliged to leave school while in the eighth grade. He got a job as a service station boy and set about studying automotive operating and repair problems. Today he is assistant superintendent of automotive equipment for the Honolulu Rapid Transit Co.

E. DUER REEVES has been elected executive vice-president of Standard Oil Development Co., central research organization of Standard Oil Co. (New Jersey). He has been a vice-president and director since 1947.

DR. AHMED MOUNIR EL-BARBARY recently became a lecturer in the Automotive Department of Cairo University, located in Abbassiah, Cairo, Egypt. Previously he was a maintenance engineer in the Cairo Water Works.

ROBERT W. McNABB is now affiliated with the Walker Mfg. Co. of Racine, Wis.

JOHN DRAKE ROGERS has become a design engineer at Westinghouse Electric Corp., Aviation Gas Turbine Division in Philadelphia, Pa. His former position was aircraft engineer for United Air Lines, Inc. in San Francisco.

HARRY KUHE has been named manager of chemical sales for Ethyl Corp. He has been connected with Ethyl since 1929, when he joined the company as a field representative in Chicago. His former post was operations manager of the Central Region.

JOSEPH GESCHELIN, past SAE vice-president and Detroit editor of Chilton publications will lecture before the Industrial College of the Armed Forces in Washington, D. C. on March 17.

ERNEST R. BREECH, who is executive vice-president of the Ford Motor Co., has been elected a director of the Manufacturers National Bank of Detroit.

ERVIN V. ANDREWS, JR. has become a city salesman for the Trailmobile Co. in Denver, Colo. He had been affiliated with Palm Bros. & Kunel, Ltd. in Omaha, Nebr.

R. M. FRANEY has been transferred from the New York office of Electro-Motive Division, General Motors Corp. to their division in LaGrange, Ill. He is foreman of the Test and Inspection Department.

OBITUARIES

WILLIAM H. EVANS

On Nov. 17, William H. Evans passed away.

Evans was born and educated in England. He has been associated with Briggs Mfg. Co., Detroit; Liquid Cooled Engine Division of Aviation Corp., Toledo; and Willys-Overland Motors, Inc., Toledo.

At the time of his death he was a designer with Packard Motor Car Co. in their Aircraft Engine Division.



TECHNICAL COMMITTEE PROGRESS

SAE Reports Best Ways To Cast Brass & Bronze

BEST available brass and bronze foundry procedures to help get greater uniformity in castings, outlined in a newly-issued SAE report, completes the last of a SAE three-volume series on foundry practice. (The other two reports cover ferrous and aluminum castings.) The new report, developed by the Brass and Bronze Subcommittee of the SAE Nonferrous Metals Committee, is titled "Process Control of Brass and Bronze Foundry Procedure."

Thesis of the report is that high standards for quality, soundness, and appearance of castings can be achieved repetitively only by most rigid control of all materials and procedures used in the foundry. In its report, the Subcommittee of leading metallurgists and foundry technicians spells out step-by-step techniques for controlling methods and materials. Based on two years' study of foundry practices, these techniques replace the costly cut-and-try way.

In the section devoted to materials, the report gives physical and chemical properties of brass and bronze casting alloys. Also shown are fabricating and performance characteristics of these materials together with the kinds of parts for which they can be used. To determine accurately the physical properties of a particular batch of metal, the report prescribes requirements for test bar design and practice.

The report also answers any questions foundrymen may have on alloying and melting copper, brasses, and bronzes. It tells them such things as which metal to melt first, at what temperatures additional metals should be added, when and how

SAE TECHNICAL BOARD

C. E. Frudden, Chairman

W. G. Ainsley	Robert Insley
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Charles Froesch	D. K. Wilson
W. H. Graves	V. C. Young
A. G. Herreshoff	H. T. Youngren

to use fluxes, and what pouring temperatures to use.

Properties of the second important type of foundry material—molding and core sands—also are given since casting soundness and appearance depend largely on the sand used. Producing a sound casting with good physical properties requires a sand with sufficient permeability to allow gases to escape through the mold while the metal solidifies. Coarse sands have best permeability; but fine sands give a better appearance.

Sand control, says the report, is essential to get and to maintain sand that constantly will give desired permeability and smoothness of casting finish. Three methods of reclaiming sand also are outlined—thermal, dry, and wet reclamation.

Casting Methods Covered

Much of the treatise is devoted to describing actual casting procedure for the sand, centrifugal, pressure, and plaster mold casting methods. In addition to telling how to handle these techniques, the report describes the equipment required, characteristics of each process as well as limitations of each.

In the discussion on sand casting, a trouble-shooting chart is given which enumerates casting defects and indicates possible causes in order of their probability. For example, rough lumps or holes on the casting surface—called sand wash—most likely are due to these factors, in the following order: (1) weak areas of sand around the gate or sharp corners at the gate, (2) too light ramming, (3) weak sand—insufficient bond, (4) rough surface of patterns or insufficient draft on patterns weakening sand on withdrawal, and (5) overbaked or poorly bonded core.

This defect-analysis chart saves the foundryman time by telling him where to look for the trouble . . . in the design, pattern equipment, mold setting, gating, molding or molding sand, cores, metal melting, or pouring.

Another important feature of the report is recommendations for salvaging castings by repairs. It tells what kinds of salvage methods are best for each type of defect. It also describes the way to make each type of repair, such as welding, impregnation, peening and blending, heat-treatment, and plugging.

Last item discussed is inspection procedures as regards both technical requirements of castings and customer-supplier relationships.

Development of the report by SAE was undertaken at the request of U. S. Army Ordnance. World War II pointed up the lack of uniformity in brass and bronze foundry practice. While older shops had the know-how, new and less experienced foundries springing up during the emergency did not. There was no acceptable way of nailing down and recording successful methods and procedures that could be duplicated in other foundries—or even in the same foundry at a later date—to get identical results.

The group that authored this report, originally the Brass and Bronze Castings Committee of the SAE War Engineering Board, feels that its work will help the brass and bronze castings industry achieve its aim of continually producing high quality castings.

Related Foundry Reports

(Copies of this report on brass and bronze foundry procedure (SP-52) are available from the SAE Special Publications Department. Price: $2.00 to SAE members, $4.00 to nonmembers. Also available are the two other reports in the foundry practice series: "Process Control of Aluminum Foundry Procedure," (SP-8) priced at $1.00 to SAE members and $2.00 to nonmembers, and "Foundry Process Control Procedures (Ferrous)," (SP-20) priced at $1.50 to SAE members and $3.00 to nonmembers.)

Members of the SAE Brass and Bronze Subcommittee that developed the new report are: J. M. Crawford, General Motors Corp., Technical Board sponsor; W. E. McCullough, Bohn Aluminum & Brass Corp., chairman; W. Romanoff, H. Kramer & Co., vice-chairman; D. Anderson, Bohn Aluminum & Brass Corp.; D. M. Bigge, Chrysler Corp.; J. W. Bolton, The Lukenheimer Co.; E. DeCapite, City Pattern Foundry & Machine Co.; H. W. Dietert, Harry W. Dietert Co.; W. W. Edens, Badger Brass & Aluminum Foundry; C. E. Evans, Sandusky Foundry & Machine Co.; G. J. Foss, Universal Castings Corp.; J. C. Fox, Doehler-Jarvis Corp.; J. C. Friedel, Jr.; Ano-Color Engineers; J. Gurski, Ford Motor Co.; H. Hodge, Titan Metal Mfg. Co.; J. F. Klement, Ampco Metal, Inc.; F. H. Mason, Chrysler Corp.; R. W. Parsons, The Ohio Brass Co.; P. J. Potter, Federal-Mogul Corp.; H. S. Ream, Jr.; Shenango-Penn Mold Co.; V. Reid, Jr., City Pattern Foundry & Machine Co.; A. T. Ruppe, Bendix Products Division, Bendix Aviation Corp.; H. M. St. John, Crane Co.; and H. G. Schwab, Bunting Brass & Bronze Co.

Consultants to the Subcommittee are G. Kalon, U. S. Ordnance, Detroit Arsenal; L. H. Adams and H. Rosenthal, Frankford Arsenal; and R. H. Bennewitz, Linde Air Products Co.

Technishorts . . .

BOLT TESTING: In its efforts to develop specifications for physical properties of fasteners, the Bolts, Nuts and Fasteners Division of the SAE Iron & Steel Technical Committee is investigating a bolt testing rig that helps get data for stress-strain records. It consists of a special fixture with a modified extensometer, used with a Templin of Microformer recorder. The extensometer is adjustable and contacts top and bottom of the bolt. Change in length of the bolt is recorded.

CORROSION RESISTANCE: Data on different kinds of corrodants encountered in the automotive industry are being gathered by the Corrosion and Heat Resistant Alloy Castings Division, of the SAE Iron & Steel Technical Committee. These materials are being studied to help the group prepare specifications for corrosion-resistant castings. Included in the list are fuels and their contaminants, hydrofluoric and sulfuric acids for removing burnt-in sand and heat-treat scale, pickling solutions, combustion products, heat-treat atmospheres, and salt air in service. The SAE Non-Ferrous Metals Committee is cooperating with the ISTC group on this project.

CAST-IRON PROPERTIES: An up-to-date report for designers on the "Engineering Properties of Cast Iron" is being prepared by the American Foundrymen's Society with the cooperation of Panel B, Castings, of the SAE Iron & Steel Technical Committee. The report will include such things as magnetic, thermal, and damping properties and suggestions for tolerances.

DRYSEAL PIPE THREADS: Revisions to the SAE Standard for Dryseal Pipe Threads recently were approved by the Technical Board for publication in the 1949 SAE Handbook. Among the additions made to the standard is an expanded section on gaging methods in the form of an appendix.

4 SAE Standards Issued For Construction Machines

SAE just released four new standards developed by the SAE Construction and Industrial Machinery Technical Committee. They are:

1. SAE Standard for Rear Mounting Dimensions for Track Type Tractors,
2. SAE Standard for Yardage Rating of Carry Type Scrapers,
3. SAE Standard for Yardage Rating of Truck and Wagon Bodies, and
4. SAE Recommended Tire and Rim Lists.

The standard for rear-mounting dimensions is divided into two separate sets of dimensions—the first for mountings suitable for belt pulley drives, rear power take-offs, cable control units, rear-mounted hydraulic units, and similar attachments; the second, for mounting space and studs for heavy-duty logging and oil winches.

The yardage rating standards establish methods of determining both the struck and heaped capacities of carry-type scrapers and truck and wagon bodies. No attempt has been made in the standard to convert capacity into pay yard terms, nor is any formula for doing this proposed.

Recommended tire and rim sizes, prepared by the Committee, are intended as a guide to engineers in future designs. Tire companies are said to regard them as important in reducing the number of tire and rim sizes.

SAE Writes Practice For Car-Wheel Chain Slots

A recommended practice for chain slots in passenger car wheels recently was approved by the SAE Technical Board.

This document, slated for publication in the 1949 SAE Handbook, recommends that cars have four chain slots to provide for installation of emergency unit chains. Dimensions of the chain slots are specified as $\frac{3}{8}$ in. minimum depth and $1\frac{1}{2}$ in. minimum width. It also is recommended that chain slot edges be smooth and that the outer edge of chain slots should be the inner diameter of the rim, or as close to it as possible.

The new recommended practice defines a unit chain as a "chain traction device designed for application to tires of vehicles when these vehicles are unable to proceed either forward or in reverse due to mud, snow, and so forth."

The unit chain is described as two standard cross chains attached to a steel side plate or wire loop in such way as to provide a spacing of about $3\frac{1}{2}$ in. between the cross chains. A webbing strap is attached to one of the side plates. This strap is passed through the wheel slot and is attached to the side plate on the opposite side of the tire with a buckle.

Only emergency use of unit chains is advised since they provide a minimum of intermittent tractive effort and can damage axles, transmissions, and differentials. Unit chains should be removed as soon as possible after the emergency has passed, says the SAE recommended practice. Driving with them on highways is dangerous because of the wide, unprotected space between the units.

SAE Participates in New American Standard For Marking Grinding Wheels, Bonded Abrasives

ISSUANCE of the revised American Standard on marking for identifying grinding wheels and other bonded abrasives is seen as a help to production men. While no panacea to the problem of grinding wheel selection, the modified system does establish symbols, arranged in uniform sequence, for the most essential characteristics of a grinding wheel.

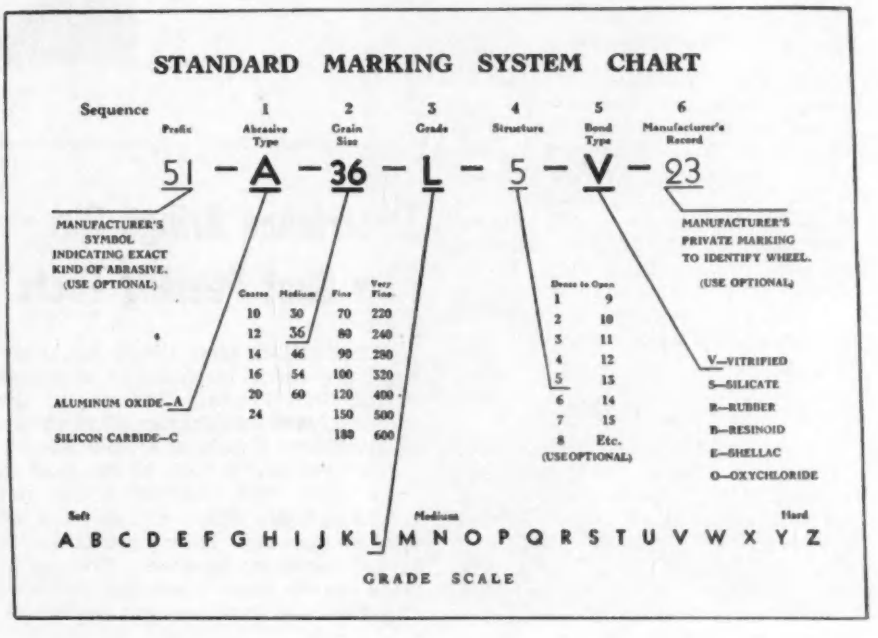
The Sectional Committee on Standardization of Small Tools and Machine Tool Elements, B5, under whose auspices the standard was prepared, is sponsored jointly by SAE, ASME, National Machine Tool Builders' Association, and Metal Cutting Tool Institute.

The original standard for grinding wheel markings, adopted in 1943, failed to get acceptance because users were still confused as to the meaning of standard grades. It was not made clear that similarly marked wheels might not have the same grinding action if made by different manufacturers.

The newly-revised standard clarifies this point; it goes on to say that "this desirable result cannot be accomplished because of the impossibility of correlating any measurable physical properties of bonded abrasive products in terms of their grinding action."

An important revision in the standard is the alphabetical system to designate grade hardness. Better provision also has been made for the wheel maker to incorporate any special symbols in the marking. See marking chart below.

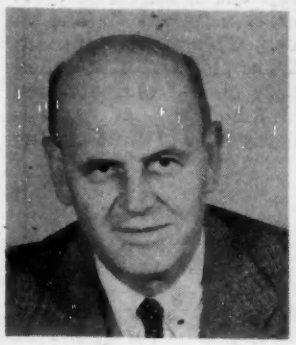
SAE representatives on the Sectional Committee at the time this revision was acted on were: W. L. Barth, General Motors Corp.; Earle Buckingham, Massachusetts Institute of Technology; P. L. Houser, International Harvester Co.; and A. H. d'Arcambal, Niles-Bement-Bond Co. Houser is chairman of the Technical Committee on Marking of Grinding Wheels that prepared the revised standard.



NEW TECHNICAL BOARD MEMBERS



FRUDDEN



HERRESHOFF



BERNARD



BRADY



COLWELL



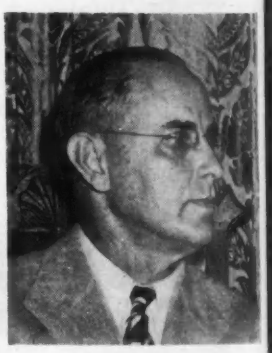
DOMAN



RITTENHOUSE



TEETOR



YOUNGREN

Frudden '49 Head Of Technical Board

C. E. FRUDDEN has been named chairman of the SAE Technical Board for 1949. Consulting engineer with the Allis-Chalmers Mfg. Co. and a past-president of the Society, Frudden has maintained an active interest in SAE standards and specifications, particularly those for tractors and farm machinery. Frudden succeeds retiring Board Chairman J. C. Zeder.

New Members

SAE President Sparrow also appointed eight new members to start three-year terms in 1949. The new appointees are: A. G. Herreshoff, Chrysler Corp.; Harry Bernard, Mack Mfg. Co.; G. W. Brady, Curtiss-Wright Corp., Propeller Division; A. T. Colwell, Thompson Products, Inc.; C. T. Doman, Aircooled Motors, Inc.; H. L. Rittenhouse, Euclid Road Machinery Co.; R. R. Teetor, Perfect Circle Co.; and H. T. Youngren, Ford Motor Co.

Retiring Members

Board members whose terms expired at the end of 1948 are: B. B. Bachman, Autocar Co.; L. R. Buckendale, Timkin-Detroit Axle Co.; G. W. Laurie, Atlantic Refining Co.; William Littlewood, American Airlines, Inc.; D. G. Roos, Willys-Overland Motors, Inc.; and C. G. A. Rosen, Caterpillar Tractor Co.

Experience Brings Out New Shot Peening Facts

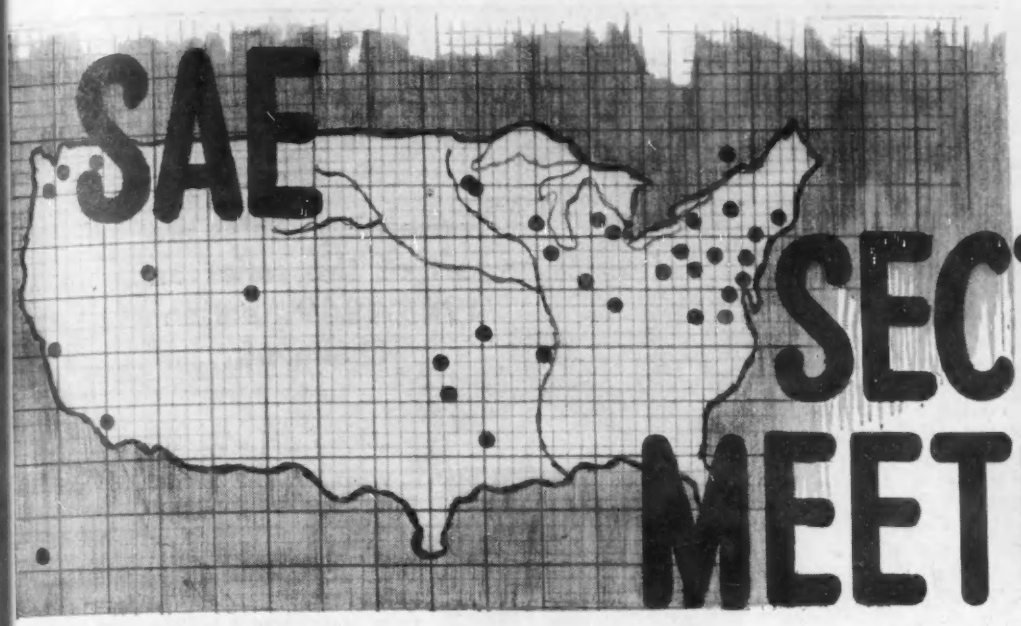
INTERESTING facts about shot peening are being disclosed at meetings of the Shot Peening Division, of the SAE Iron & Steel Technical Committee, in developing a manual on the subject.

For example, it was noted that in some cases shot peening brings out cracks in gears which do not show up prior to peening. Here peening serves as an inspection method. Trouble in these cases was corrected without changing the shot peening procedure, but by changing the draw temperature.

Effects of elevated temperatures on peening was said to be another item worth considering. Experience has shown that effects of shot peening are lost at 500F.

One engineer reported that gears not peened produce a metallic noise when run dry. Shot peening eliminates this noise.

By developing a manual for engineers, designers, and draftsmen that tells them of these and many other possibilities and limitations of the shot peening process, the Division hopes these men will better understand the problems confronting them in using the process.



SAE SECTION MEETINGS

J. G. Holmstrom Attacks Excess Weight in Trucks

—J. B. TOMPKINS, Field Editor

BRITISH COLUMBIA Group, Dec. 9—"Taking weight out of trucks is today hotter than a pistol!"

So said Kenworth Motor Truck Corp.'s vice-president and general manager, John G. Holmstrom.

Speaking to members and guests who packed the ballroom of Vancouver's Hotel Georgia, the feature speaker of the booming western Canadian group's fourth open meeting of the 1948–1949 season stressed to the timber-conscious audience that "highway operations are the reserve of logging where 'beef' is essential."

Labeling the AASHO Code "the joker" in lightweight truck design, Holmstrom admitted that "all in all it was not bad" and claimed that use of aluminum, magnesium, and other weight-saving metals and devices should pay for itself in three years' operation with the higher freight payloads permissible.

To drive home his weight-saving points, the veteran Kenworth engineer cited an instance of a petroleum hauler with a mileage rate of 40¢. His cost was 35¢. Weight saving gave him an extra half cent a mile.

"The easiest way to reduce weight is to reduce the specifications," advised Holmstrom. Reminding his attentive audience that "aluminum does not cost more to maintain," he advocated leaving off parts sometimes nonessential. An oil filter, for instance, for a large "for hire" truck weighs some 45 lb. An extra fuel tank may run to 120 lb extra weight—hardly worth packing merely to save sometimes an extra 2¢ per gal on fuel at "the other end of the line." Sanders approximate 125 lb plus 200 lb for the sand. Aluminum casings for transmissions, axle housing, and hubs all contribute to greater legal payloads. Kenworth pioneered, prewar, with the use of aluminum brake shoes.

Aluminum hubs alone, Holmstrom claimed, save 46 lb per rear hub and 25 lb apiece up front. Substitution of aluminum for the rear axle housing can account for a 160-lb saving in vehicle weight. Aluminum hoods he termed "a wonderful idea," returning a saving of 72 lb on Kenworths.

Most difficult problem for weight-minded designers is the cab, claimed Holmstrom. Aluminum cabs won't "take the beating" of steel cabs. Kenworth, however, cuts pounds through the use of lightweight doors and back panels with the balance remaining steel.

Tire manufacturers drew a harpoon

Continued on p. 91



Addressing British Columbia Group, J. G. Holmstrom beams as he warms up to his subject of saving weight in trucks

SAE Section Chairmen

These biographies are part of the series on 1948-1949 Section Chairmen



POULSON

POULSON
. . . . of Oregon

It was back when trucks on the highway and in the woods of Oregon were curiosities that John Stanley Poulson got his start in the automotive industry. Now that the shipping and logging industries couldn't get along without trucks, Stan has accumulated 25 years of experience in truck and engine companies.

As a young man with a keen desire to be associated with mechanical work, he went to Salt Lake City to find a place in the field. The White Motor Co. admitted him—not to the mechanical end of the business—but to the office end. From Salt Lake City, White transferred him to Portland, then to Seattle, and back to Portland. Then in 1939, he was offered and accepted the position of manager of Cummins Diesel Sales of Oregon, in Portland, where he still holds forth.

Study at the Walton School of Commerce in Chicago had given him background for business. Previously he had attended Brigham Young University in Provo, Utah and grade school in southern Utah.

In his spare moments, he is an enthusiastic sports fan. He follows the Portland Beavers baseball club avidly and roots himself hoarse at football games.

—B. M. Smith, Field Editor



WOLCOTT

WOLCOTT
. . . . of Syracuse

It's "like father, like son" with the Wolcotts. Samuel Wolcott's father was one of the first Nash dealers in the Syracuse area, and Sam has a strong interest in motor vehicles, too—especially fire-fighting equipment.

He took a year out of his engineering studies at Cornell and spent it as an automobile mechanic. Another summer he worked as an apprentice engineer at the American LaFrance Foamite Corp. For his senior year at Cornell, he elected the automotive option of the engineering curriculum.

That summer apprenticeship was the beginning of a long association with American LaFrance. As soon as he had received his mechanical engineering degree from Cornell in 1936, he went back to American LaFrance's experimental engineering department. There he worked on design and development of engines, centrifugal pumps, pump primers, and relief valves.

When Cornell set up a wartime training school for Naval officers, Sam became an instructor in experimental and diesel engineering. That was in 1942. He gave instruction in diesel engines, spark-ignition engines, governors, compressors, boilers, refrigerators, lubrication, and thermodynamics.

Still at Cornell in 1943, he began work toward a master's degree in mechanical engineering, majoring in fluid mechanics and minoring in experimental engineering. He received his master's degree in 1945. He has a New York State professional engineer's license, as well.

Now he is back again at American LaFrance as engineer in charge of engines and pumps.

He has a reputation for getting from his home in Elmira to SAE section and governing board meetings in Syracuse no matter how bad the weather or traveling conditions are.

Besides his service to SAE, Wolcott has served the Cornell Club of Elmira as president, the Watkins Glen Yacht Club as director and regatta chairman, and the Elmira Junior Chamber of Commerce as director. He is a member of the Elmira Glider Club, too, and holds three licenses.

—W. F. Burrows, Field Editor

You'll Be Interested To Know . . . .

SAE BY-LAW B7, BY COUNCIL ACTION on Jan. 14, 1949, has been changed to read: "A former member who applies for reinstatement may be restored to membership by action of the Council."

H. K. CUMMINGS, NATIONAL BUREAU OF STANDARDS, has been reappointed SAE representative to the American Documentation Institute.

A NEW SAE STUDENT BRANCH has been established at the University of Illinois. Started less than a year ago, this student group now has 112 members and is continuing to grow.

from the engineer credited by British Columbia Group Past-Chairman P. J. Schrodt with "building more trucks and buses on the Pacific coast than any other person."

"Somebody ought to do something about tires," cried Holmstrom in closing his address. "They increase a bit each year. They're either chiseling on price or chiseling on size. They haven't done a thing about weight saving!"

Host for the meeting was Vancouver's Ferguson Truck & Equipment Co., Ltd., British Columbia distributors for Kenworth trucks. Meeting chairman was H. L. Hinchcliffe, operations manager for Shell Oil Co. of British Columbia.

Drew Charts Growth of Motor Transport

—W. F. SHERMAN, Field Editor

DETROIT Section, Nov. 1—Against a background of live and interesting statistical information that would make some startling charts of the growth of motor transportation, V. M. Drew, director of research, Fruehauf Trailer Co., addressed the Detroit Section Truck and Bus Activity Meeting in the Horace H. Rackham Educational Memorial.

He depicted the motor transport industry as gaining about 260% in face of a slightly declining rate of national economy as a whole, between 1929 and 1939. At the same time that ton-miles carried by motor vehicles increased from 18 billion to 50.2 billion, between 1929 and 1939, the number of commercial vehicles increased from 3½ million to 4½ million, indicating an increase in individual unit efficiency amounting to 460%, he declared.

In the wartime period, truck transportation suffered from a sort of "empty back-haul" system but, notwithstanding, did not fall below a 61 billion ton-mile performance in its lowest year, he asserted. Performance in 1948 is expected to be recorded at about 85 billion ton-miles, a 25% increase over previous peaks. A normal and economically sound "two-way haul" system exists again.

These gains have been made despite lack of suitable roads in all earlier years and under the handicap of a system of highway barriers erected by legislation and regulation.

Drew described some of the efforts that are now being made on an engineering basis to increase understanding of the transport problem and to improve the nation's use of its highway system. In particular, he referred to an important truck-highway test program under direction of the National Highway Research Board Project Committee No. 5 in which there is cooperation of the Automobile Manufacturers Association, the Truck-Trailer Manufacturers Association, the American Trucking Association, Inc., the National Council of Private Motor Truck Owners, the Department of the Army, the Pennsylvania Department of Highways, the Pennsylvania Turnpike Commission, the U. S. Public Roads Administration, major eastern oil companies, and the rubber industry.

Such tests are accompanied by the use of electrically actuated strain gages on bridge structures, because they have been the so-called "weak-link" in transport facilities.

The entire project is one dealing with the economics of sizes and weights and is expected to have important bearing on future trends in motor transport.

Drew outlined trends in vehicular equipment. Prior to the war 20- and 22-ft trailers were usual. Since the war 27.5% of the trailers sold (1948) are 28 to 30 ft in length, 16.6% are over 32 ft in length, and only 1.4% are less than 22 ft.

Power units are showing an increase in size; average loads increased 40% between 1936 and 1944, and the nationwide frequency of gross vehicle combinations of 50,000 lb and above increased slightly over seven times from prewar years to 1946.

Noville Discusses Flying with Byrd

—L. E. MORGAN, Field Editor

SAN DIEGO Section, Dec. 3—George O. Noville related to SAE and IAS members some of his experiences at the north and south poles with the Byrd Expeditions, illustrating his talk with a motion picture.

Airplanes in those days were difficult enough to fly in good weather, but it was his job to fly them at temperatures as low as – 80 deg F. Solutions to some of the problems experienced then are now part of the present-day airplane, Noville said, giving the oil-dilution valve as an example.

Williamsport Sees Race and Tire Films

—H. W. EPLER, Field Editor

WILLIAMSPORT Group, Dec. 6—Two colored sound movies, "Crucible of Speed" and "The Building of a Tire," furnished by the Firestone Tire and Rubber Co., substituted for the scheduled talk, which was postponed.

"Crucible of Speed" told the history of the Indianapolis races from 1911 to 1946 with particular reference to the races as a proving ground for ideas and innovations which later were incorporated in passenger cars.

The rear view mirror, for instance, was first used by a racing driver who decided to drive without a mechanic, one of whose duties had been to look back and report the positions of the other racing cars.

Other advancements first introduced in the Indianapolis races were four-wheel brakes, hydraulic shock absorbers, supercharging, independent spring suspension, and balloon tires. Along with these came steady testing and improvement of tires, since a run of 500 miles on the speedway is considered equivalent to 50,000 miles under ordinary driving conditions.

"The Building of a Tire" showed each step in the manufacture of a tire from raw material to finished product. Animated drawings supplemented photographs of actual manufacturing operations.

After the meeting, members had the opportunity to hear their own voices through a tape recorder made available by Harry Lavo and Arthur Altemose of Alvo Recording Co.

Guided Missiles Pioneered by Navy

METROPOLITAN Section, Nov. 18—The United States Navy's development of guided missiles began long before German V-1 and V-2 bombs were raining on England, Capt. Delmer S. Fahrney, USN disclosed in his talk on "Navy Pioneering in Guided Missiles."

In fact, the V-1 and V-2 were not even "guided missiles" in the modern sense of the term, he said. There was no means of determining and correcting errors in their course after they were launched.

Fahrney explained that the evolution of the guided missile has involved the integration of three major phases of development: jet propulsion, guidance and control, and airframe design for ultra high speeds.

He described how demand for a full-scale radio-controlled aerial target for gunnery training and evaluation of armament opened one of the early chapters in the history of the Navy's work on guidance and control.

The Bureau of Aeronautics established a project for experimentation with radio-controlled pilotless aircraft back in 1936. Limitations on funds dictated conversion of obsolete aircraft for the purpose, and initial effort was directed toward developing radio control and stabilization equipment.

Special emphasis had to be placed on remote control for landing and take-off because the Navy could not afford to expend even obsolete aircraft after each test flight.

Principles of the system of radio

guidance, as outlined by the speaker, were: automatic stabilization was maintained in flight by an internal closed-loop electrohydraulic servo system which received its error signals from a system of displacement and rate gyroscopes when the airplane was disturbed about its three axes.

Remote control for maneuvering the aircraft was effected by superimposed radio signals which caused changes in the reference positions of the displacement gyroscopes, thereby introducing the equivalent of an error signal in the stabilization system and producing movement of the appropriate control surfaces of the aircraft.

Controls were placed on the ground for take-off and landing, and were carried in another aircraft for air operations. The robot airplane had to be kept in sight, of course.

With this system, the first successfully completed pilotless flight in this country was made late in 1937.

After describing television-guided radio-controlled pilotless aircraft and filling in other chapters in the Navy's guided-missile effort, Fahrney predicted that this country will maintain leadership in the field.

Stratocruiser Benefits from Double-Deck Design

—F. C. WILDHAGEN, Field Editor

NORTHERN CALIFORNIA Section, Dec. 20—Design goal for the Boeing Stratocruiser was to exceed both established government standards and the requirements of airlines and their passengers in airplane efficiency, performance, safety, utility, and luxury.

How successful the design turned out to be was revealed by E. E. Miller, assistant sales manager of the Boeing Airplane Co.

Probably the most unusual single feature of the design was its double-deck body design. This shape was the logical choice for a cargo and troop transport, Miller explained, since it enabled Boeing to achieve in an airplane very little larger than existing transports more useful space as well as flexibility, both in load-range characteristics and in interior accommodations.

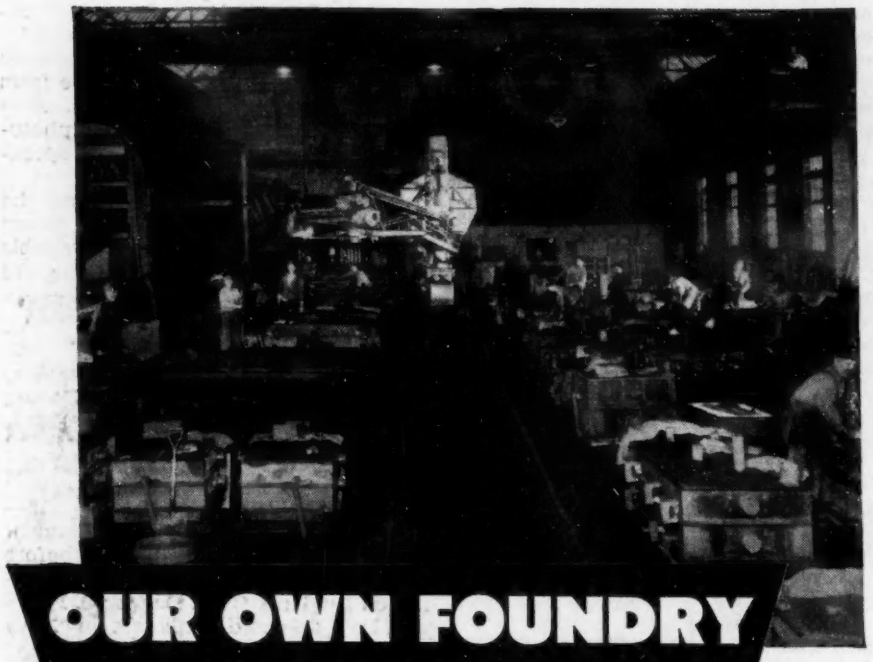
Approximately 13% higher ratio of useful load to weight empty was attained than that of competitive transports. This represented approximately 5800 lb of weight, or 25% of the total payload and a sizable percentage of the potential revenue. Approximately 4000 lb could be assigned to "plus" features. At a 70% payload factor, the Boeing airplane rated 128% compared to 99% for competition "A" and 97.6% for competition "B".

This indicated that the airplane was capable of earning more profit, thereby producing a greater return on the original investment. The Stratocruiser has proved the accuracy of the forecasts and the soundness of the decisions. The Stratocruiser has been certificated with performance exceeding contract guarantees and bettering many CAA requirements and has received whole-hearted approval of customer airlines.

The Stratocruiser operates with payloads in excess of 20,000 lb for all ranges up to 4000 miles and for altitudes up to 30,000 ft and with cruising speeds up to 340 mph. It is estimated that the Stratocruiser, with more powerful engines, can fly nonstop coast-to-coast in about 5 hr, Miller added.

Extra material and strength are incorporated in the airplane structure to allow for growth. Stress analysis and static tests substantiate the Stratocruiser for a take-off weight of 147,000 lb at the CAA required ultimate load factor of 3.75, Miller said.

During a dive test the Stratocruiser attained a true air speed of 499 mph —almost jet fighter speed, he reported. The upper deck allows over 65 cu ft of



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MEANS BETTER CONTROL OF
YA RADIATOR QUALITY

Our own foundry, along with excellent pattern shop, well equipped tool room, etc., help make Yates-American radiator manufacturing facilities the most complete in the industry.

Translated into benefits for you, this means not only better control of quality, but greater ability to satisfy exact requirements, delivery schedule second to none in the industry, *more satisfactory service right down the line.*

Let us show you how well we can fill your radiator needs for motor and industrial trucks, tractors, compressors, locomotives, power plants—whatever your heat transfer requirements may be.

YATES-AMERICAN MACHINE CO.
HEAT TRANSFER DIVISION
BELOIT, WISCONSIN

volume per passenger, under full load conditions.

The chairs, a product of 100,000 man-hours of research and design, have been approved by highly critical sitters, ranging in size from a 75-lb child to a 350-lb man. The lower deck lounge is a good illustration of space and weight being utilized for passenger luxury. For the first time the air traveler can really move about, have a change of scenery, and order a snack or a cocktail. If future traffic demands, lounge seats can be sold for revenue or the space utilized for an additional 5000-lb cargo.

Colorado Visits 86th Fighter Wing

—D. H. LAMB, Field Editor

COLORADO Section, Dec. 7—The 86th Fighter Wing of the Colorado Air National Guard was host to the Colorado Group at the guard headquarters at Buckley Field in Denver.

Exhibits of navigational, gunnery, and flight training equipment were demonstrated. A radar unit, Link trainer, and cutaway jet engine were on display, as were many training and service aircraft.

The latter part of the evening was devoted to movies showing the air war in the Pacific and in Europe. Col. J. C. Moffitt, commanding officer of the 86th, and Col. Hines gave informal talks on the organization and functions of the Air National Guard.

The band of the Fighter Wing entertained with several selections.

Maintenance Expert Addresses St. Louis

—A. D. TRACER, Field Editor

ST. LOUIS Section, Jan. 4—Some of the maintenance procedures that give the 1200 buses and 100 passenger cars and trucks of the St. Louis Public Service Co. the record of the lowest maintenance cost per mile in commercial transportation in the United States were outlined by Adam Ebinger, superintendent of automotive equipment.

Routine inspections and complete preventive maintenance, including even a daily wash job for each bus, are performed at eight garages. The main overhaul shop does all unit repair. In 1948 almost 500 gasoline and diesel engines were rebuilt at the main shop, and a production line completely rebuilt 270 old-style buses, Ebinger said.

All brake work is done at the main shop. The battery shop designs, builds, and maintains all batteries.

Each bus is scheduled for a body overhaul and paint job each two and one-half years.

According to Ebinger, long engine life depends on good quality bearings and good oil. His shop changes oil every 8000 miles in heavy-run buses and every 4000 miles on "trippers." He credits frequent oil changes with keeping hydraulic transmissions in service, when many other operators are experiencing costly failures.

Through the maintenance record system, a thorough check is kept on all units. Every engine, transmission, differential carrier, generator, compressor, and other unit is assigned a number. A cross-indexed card file system shows maintenance data for each unit.

Central Illinois Tours Caterpillar Engine Plant

—R. V. LARSON, Field Editor

CENTRAL ILLINOIS Section, Dec. 13—Nearly 400 engineers from Peoria and Springfield and students from Bradley University and the University of Illinois toured Caterpillar Tractor Co.'s new engine factory from rough casting stores to the run-in floor.

They saw one of the most modern layouts for engine manufacture in this country. A tremendous variety of parts is produced here for eight different basic engines. In spite of complexity, many of the machine lines are conveyerized. Efficient material handling characterizes the entire plant. Visitors noted ingenious compromises between completely powered conveyers and small-batch production.

Particular effort has been made to keep the engine assembly clean. Water-washed air is continually circulated. Assembly lines are separated from the machine shops by a masonry partition.

All engines are run in and their power output checked on dynamometers on the run-in floor.

On the run-in floor are a number of test cells, each accommodating two engines. Cells are equipped with electric motoring motors and eddy-current dynamometers.

Section Holds Meeting with MTA in Los Angeles

—R. V. LINDBERG, Field Editor

SOUTHERN CALIFORNIA Section, Nov. 18—Guest speakers at the joint dinner meeting held with the Motor Truck Association were John G. Holmstrom, vice-president and general manager of Kenworth Motor Truck Corp., and Judge Roger Pfaff of the Los Angeles traffic court.

A large audience, including many of Southern California's heavy truck operators, heard Holmstrom discuss why weight should be saved in trucks and how it can be done.

Saving weight is worthwhile when it saves money. As an example of such a case, Holmstrom cited the use of aluminum for tanks. Over a period of years, aluminum saves $1.50 per lb, although it increases list price only $1.12 per lb, he said.

Aluminum isn't the solution in every



case, however. Aluminum counterparts of 1044-lb steel springs save 362 lb, but the aluminum springs must be large because the aluminum has only one-third the modulus of elasticity of steel and poorer bearing properties. Design and production costs would overbalance weight savings of aluminum springs, Holmstrom explained.

The easiest method of reducing weight, he said, is to leave something off. He warned that adding extras adds weight. Sanders add 200 lb or more; wheels, 100 lb; forward brakes, 200 lb; large battery, extra 40 lb, to say nothing of extra fuel tanks, he reminded prospective purchasers.

Jerry McBrearty, chief structural engineer for Lockheed Aircraft, noted the shear wrinkles in truck panels and said that use of the panels as structure would be better engineering—at least from an aircraft engineer's viewpoint.

He cautioned manufacturers relying on aluminum that this strategic material could become restricted overnight in the event of national emergency.

SOUTHERN CALIFORNIA Section, Dec. 1—For the annual production-engineering meeting, 220 members and guests toured the plant of the Aluminum Co. of America at Vernon, Calif.

The tour through the ingot department, press department, extrusion area, forge room, and die shop showed the complete sequence of processing and fabrication from raw aluminum to the finished product.

U. S. Navy May Organize Reserve Automotive Units

—RENE GUILLOU, Field Editor

HAWAII Section, Dec. 20—It is now considered that, in the event of another war, transportation would be such an immediate and vital problem as to justify the organization in peacetime of Automotive Transportation Units in the Naval Reserve, according to Lt.-Com. J. H. McAuliffe, Jr. USNR, and Capt. C. W. Porter USN.

At a dinner meeting of the section, they discussed sponsorship by the section of such a unit in the Naval Reserve.

During the early weeks of World War II, the first hastily organized Construction Battalions were in forward areas and at work with automotive equipment before they could be supplied with uniforms. Training and organization were rapidly developed, and as the war progressed it became evident that the original general-purpose CB units, "ready for anything," should be supplemented by units specialized to provide transportation, it was explained.

Capt. Porter, who was associated with the organization of the Navy's construction battalions in 1941, outlined the earlier history of those units. The first American advance base in the Pacific, said Capt. Porter, was constructed in 1813 in the Marquesas Islands, when 4000 natives under direction of their chiefs erected in one day a complete village for use of American naval personnel in repair of the frigate Essex.

The meeting was closed with a movie showing the activities of naval automotive transportation units in World War II.

Designers Discuss Interior Styling

—W. F. SHERMAN, Field Editor

DETROIT Section, Nov. 15—A unique opportunity to increase knowledge in both technical and styling aspects of automobile interiors was created when the Detroit Section Program Committee offered a program teed off by James Watt, formerly director of purchases of interior trimming materials of Ford Motor Co., and followed up by Helene Rother, Detroit automotive consultant with Parisian background, and George W. Walker, widely known stylist.

"Are we doing a good job on body interiors?" was the topic question posed by A. R. Lindsay, of the Budd Co., chairman of the evening.

Watt, cognizant of the controversial aspects of the question, agreed that maybe apparent progress had not been as great in interior treatment as it has been in other units of vehicles. Seats and fabrics are apparently not much changed through the years, and it could be said that we have made the cycle from plain treatment to pleats, without paying much attention to trends.

Most engineers, he alleged, have hesitated to learn much about textiles; they rely on textile designers from the mills who, in turn, are limited by such factors as mill equipment. There is need for more of the decorator's touch and for increased budget allowances that will make it possible to accept the advice that can be obtained on this important subject, Watt said.

Helene Rother, whose efforts have encompassed items ranging from jewelry and accessories to several of today's automobiles, said that "even the Army is ahead of industry" in employing the talents of women and



advocated that the industry should catch up.

"Women control 70% of the wealth of the nation and are determined to spend 120% of it," was advanced as one of the reasons why the industry should keep step with the taste, color preferences, and style desires of women who influence the purchase of motor cars.

"People don't know what they want but won't be satisfied until they get it" was her piquant observation, and the bell-ringing remark of the evening.

Of women, she said, "they are gadget conscious, and it is surprising what they want—heating outlets for warming baby food, safety belts, and umbrella holders. Gadgets sell houses today. Gadgets will sell cars tomorrow." This was Miss Rother's summary.

Women buy, or influence the sale, 85% of the time, Walker declared. Whoever the buyer, when the choice rests between two items, the public buys the more attractive one.

The function of the industrial designer is to design to sell, leaving all technical and engineering phases to engineers. Essentially, the job is to compromise the art of the illustrator with the science of the engineer, to bridge the gap between sales and engineering, he said.

As to interior color, Walker cited the fact that most buyers order gay checks or plaids for seat covers. He said the manufacturer spends $4.00 or $5.00 per yd for the necessary 15 yards of upholstery in the car, after which the buyer conceals this $70.00 investment under $30.00 worth of seat covers. The irony of it is that the $70.00 worth of material won't wear any longer than plain duck at $1.50 per yd.

He advocated tailored nylon for a quick change, with zippers and push buttons, over plain duck.

Guided Missiles Research Reviewed

—E. L. KORB, Field Editor

PHILADELPHIA Section, Dec. 8—Lt.-Col. McCutcheon USMC, described work done on guided missiles by the Naval Research Laboratory, and the Bureaus of Aeronautics, Ordnance, and Ships from 1916 to about 1945.

The modern guided missile is just beginning to emerge from a long period of development in three fields, he said, naming propulsion, airframe aerodynamics, and guidance.

Three short moving pictures were presented showing the performance of a wide variety of missiles. Some of these devices were remotely controlled, either from the ground or from an airplane. In this manner fighter planes were operated in long flights during which control was transferred from ground to airborne personnel. Practice bombing missions were shown being carried out by gliders (known as glombs) and by powered aircraft loaded with bombs and controlled from nearby aircraft so that they would ram the target. Remotely controlled small airplanes are apparently quite useful for target practice.

Even more spectacular was the performance of self-guided missiles which use radar to guide themselves into a target.

Lt.-Col. McCutcheon was introduced by Com. Paul J. Burr USN, who acted as technical chairman of the meeting.

Colby Describes New Army Vehicle

—A. D. TRAGER, Field Editor

ST. LOUIS Section, Dec. 14—Ease of maintenance is of prime importance in all tactical vehicles, said Col. J. M. Colby of the Detroit Tank Arsenal, who explained how the new wheeled units have been designed to incorporate all possible labor- and time-saving devices.

Present wheeled vehicles of the Army now utilize the aircooled engine tested by peacetime Task Forces Williwaw, Frost, and Frigid under the utmost adverse weather conditions of the Arctic, he reported.

His explanation was that water is as difficult to obtain in cold climates as ethylene glycol. Engine protection required for water-cooled power units can be eliminated entirely by use of aircooled engines. With no need for water jackets or radiator, the aircooled engine of the same horsepower as the conventional type takes only about as much space as the radiator and fan of a water-cooled installation and in addition weighs only 30% as much, resulting in greater cargo-carrying capacity with a smaller truck.

Torque converter transmissions, which eliminate the clutch mechanism and give variable power units of less weight and bulk than geared transmissions, were found to be easier to operate and also improved vehicle, driver, and maintenance efficiency, he said.

By the use of torsion-bar wheel sus-

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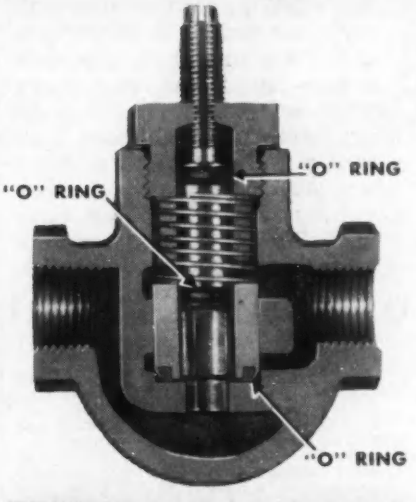
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Because there are no commercial counterparts for most of the Army's requirements, all tactical military vehicles are designed by the Army engineers, with men from competitive automobile manufacturers' engineering departments lending their assistance, it was explained.

Proudfoot Reviews SAE Lubricant Specs

—W. F. BURROWS, Field Editor

SYRACUSE Section, Dec. 3—This section joined ASCE, AME, AIEE, and the New York State Society of Professional Engineers to hear David Proudfoot, chief engineer of the Pennzoil Co. trace the progress made in lubricants down through the years.

He pointed out the present SAE specifications for engine lubricating oils and rear axle lubricants, going into each specification in detail to show how it meets the needs of the automotive industry.

Aberdeen Builds New Wind Tunnel

—R. E. JOHANSSON, Ass't. Field Editor

SOUTHERN NEW ENGLAND Section, Dec. 9—Some of the projects now under way at the Exterior Ballistics Laboratory at Aberdeen Proving Ground are construction of a new wind tunnel, collection of data on drag functions of projectiles, calculations of flow around axially symmetric bodies for use in studies of base pressure, and studies on the stability of shells, according to R. H. Kent, associate director of the Ballistics Research Laboratories.

He reported that a new wind tunnel with a flexible nozzle is now nearing completion. Contours of the flexible nozzle are altered through hydraulic jacks. Mach numbers in excess of 4 are obtainable. Three 3000-hp compressors and two 2000-hp compressors supply the new tunnel and a fixed-nozzle tunnel built in 1944.

Comparison of test results from the German Kochel tunnel with test results collected at Aberdeen showed close agreement in moment coefficient values, although drag coefficient data varied widely. The discrepancy is attributed to differences in support systems.

Reviewing the work of the free-flight aerodynamics group, Kent told of measurements of drag on bullets made through photography. With a combination of camera plates and mirrors, two projections of the bullet in free flight are obtained at each of 25 stations. An electrostatic charge on the bullet triggers the spark illumination for the photographs. Drag is determined through the retardation of the bullet.

Complicated calculations of flow around axially symmetric bodies are being made on the 17,000-tube Eniac, Kent said, adding also that a new model of the Eniac with only 4000 tubes but better memory characteristics is being developed.

New computations of wind effects on missiles prepared by the theory branch permit fuel feed to be regulated for greater duration of flight, Kent reported. It has been discovered that, due to the effect of the earth's rotation, a rocket fired 100 miles up will land about one mile to the west of its take-off point.

Michigan Chemicals Stem from Trapped Sea

—H. F. STAPEL, Field Editor

WESTERN MICHIGAN Section, Nov. 18—How Michigan's chemical industry has been developed from salt deposits was explained by Gordon Anderson to the 50 couples attending the annual Ladies' Night.

In prehistoric times, this part of the country was covered by a salt-water sea. As the land developed, parts of the sea were trapped beneath the soil, said Anderson of Dow Chemical Co.

In 1890 the Dow company began to recover bromine for potassium bromide, a sedative. It also manufactured chlorine. Eventually the company got into manufacture of chloroform, their first organic product, from brine, sulfur, and charcoal. By 1914 Dow had developed a process for the manufacture of synthetic phenol and had become the largest producer, a position maintained ever since.

The company soon branched out to produce chemicals for medicines, flavorings, dyes, preservatives, and many

Silicone News

DC SILICONES

What's Essential?

Buttons and bows may be essential to the little woman; a box of La Coronas may be essential to us. But that's a purely relative use of the word. For something that is absolutely essential we point to certain industrial motors . . . for example, pump motors that supply water to a processing plant. They're the kind of motors that deserve Silicone Insulation.

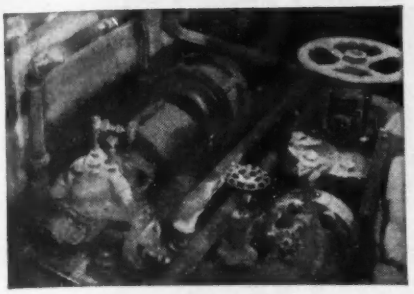


PHOTO COURTESY PURE OIL COMPANY

Both of the 10 h.p. motors which supply water to the Pure Oil Refinery at Midland, Michigan, are silicone insulated to assure continuous operation under adverse conditions.

These two pump motors are located in a sub-basement near a river that overflows every spring. Ventilation is poor and humidity is always high. Originally insulated with Class "A" materials, both motors failed the first time they were flooded out. They were then rewound with Silicone (Class "H") Insulation.

Pure Oil specified Silicone Insulation because it offers much more protection to motors exposed to excessive moisture. In several instances, silicone insulated motors that were submerged by flooding have been hosed off and put right back into service. Accelerated life testing and actual performance records have proved that this new class of insulation developed by Dow Corning has at least 10 times the life and 10 times the wet insulation resistance of the best insulating materials previously available.

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STUDENT NEWS

Wayne University

Joseph Geschelin, SAE past vice-president and Detroit editor of Chilton publications, addressed engineering students at Wayne University on Jan. 6. The talk and discussion dealt with some of the basic advances in the manufacturing art and the cooperation necessary between designer and the production department.

University of Oklahoma

SAE and ASME student branches met jointly to hear John H. Baird of the Lubrizol Corp. particularize the role of additives in prevention of corrosion, oxidation, and wear of machine bearing surfaces.

Additives prolong engine life, reduce maintenance costs, give better lubrication, and permit less frequent oil changes, he said.

—J. H. Lee, Field Editor

Massachusetts Institute of Technology

Ease of steering is the primary purpose for individual suspension, Prof. Joseph Ulman of M.I.T. told the Student Branch on Dec. 9.

He refuted the usual claim that the major reason for the use of independent suspension is the so-called knee-action. Use of a stabilizer bar prevents much of the smoothing action associated with the suspension, he said. Major reason for using independent suspension is that it enables the various steering assemblies to maintain the correct camber, according to Ulman.

As an illustration, he compared the action of the old single suspension and the independent suspension when stressed by the action of braking to a stop.

In the single suspension, downward movement of the front end caused the castor angle to change from positive to negative. The net effect was that the angle, instead of causing the wheels to straighten themselves out, as it is supposed to do when the wheels are turned slightly, acted as it would when going in reverse. It caused the slightly turned wheels to turn even more.

The individual suspension when similarly stressed tended to maintain the angles and thus preserved the desired effect of the angle. In modern automobiles, the angles are very small,



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but the necessity of preserving even the small angles makes the use of independent suspension very desirable.

—P. J. Byrne, Field Editor

Detroit Institute of Technology

First step in the Student Branch's tour of the Great Lakes Steel Corp's. Ecorse, Mich., plant on Nov. 23 was a stop at the bessemer converters. These are fed from blast furnaces at another plant, the molten iron being brought in by "thermos bottles" mounted on railway cars. These bessemer converters are used mainly to speed melting and refining processes for the open hearth furnaces.

The next stop was at the charging side of the 16 open hearths. Each was charged with scrap iron, pig iron, and molten iron from the bessemer converters, and when tapped produced about 130 tons of steel.

The steel is then poured into a ladle which in turn fills the ingot molds. The molds are cooled outdoors and the ingots are removed, and taken to the soaking pits where they are prepared for the rolling mill. Here they are heated uniformly throughout and brought to rolling temperature.

From the soaking pits the ingots are conveyed to the blooming mill and rolled into billets and slabs. After the billets are rolled, they are taken to the bar and merchant mills where they are rolled into rounds, squares, and flats. The slabs are taken to the rolling mill and rolled into sheets of various thicknesses.

At the hot-strip mills, the heated slabs are sent through a series of rolls or stands in one continuous line and removed in the form of coils of sheet steel. These coils are then taken to the pickling plant, where an acid bath removes excess scale. Further finishing of the steel is done by cold rolling and cutting into specified lengths by "flying shears", a unique method by which a continuous coil of steel is cut as fast as the coil is unwound.

—David Gorte

Coming Events

Cont. from p. 65

Colorado Group—Feb. 10

Eddie Otts Broadmoor; dinner 6:30 p.m. Dinner dance. Door prizes and brief entertainment.

Detroit—Feb 16 and Feb. 21

Feb. 16—Large Auditorium, Rackham Educational Memorial; dinner 6:30 p.m.

Traditions, Trends and Tendencies in Car Body Design—William B. Stout, Stout Engineering Laboratory, Phoenix, Ariz.

Feb. 21—Rooms A, C-D, and E-F-G, Rackham Educational Memorial; meeting 8:00 p.m. Panel Meeting—Bodies, Brakes and Personal Aircraft. Speakers: Junior members. Discussors: Senior members. Social hour following meeting—Admission: 25¢ per person.

Indiana—Feb. 10

Hotel Antlers, Gold Room, Indianapolis, Ind.; dinner 7:00 p.m. Motor Car Suspensions—L. W. Klein and W. L. Norris, The Gabriel Co. Illustrative slides.

Kansas City—Feb. 8

Location to be announced; dinner 6:45 p.m. Development of Automobile Fuel and Anti-knock Testing Procedure—Speaker to be announced.

Mid-Continent—Feb. 12

Biltmore Hotel, Oklahoma City, Okla.; Meeting 8:00 p.m. Torque Converters—W. F. Shurts, Twin Disc Clutch Co.

Mohawk Hudson Group—Feb. 9

Hale House, Union College, Schenectady, N. Y.; dinner 6:45 p.m. Meeting (will be held in Electric Engineers Building, Union College) 8:00 p.m. Diesel Engines—O. D. Treiber, consulting engineer, Hercules Motors Corp.

Northern California—Feb. 12

Fraternity Club, San Francisco, Calif.; dinner 8:00 p.m. Annual dinner dance with entertainment.

Northwest—Feb. 4

Hotel Gowman, Seattle, Wash.; dinner (time to be announced). The G. M. Training Program and Their Schools—Leonard L. Scheibel, western area service manager, GMC Truck and Coach Division.

Philadelphia—Feb. 9

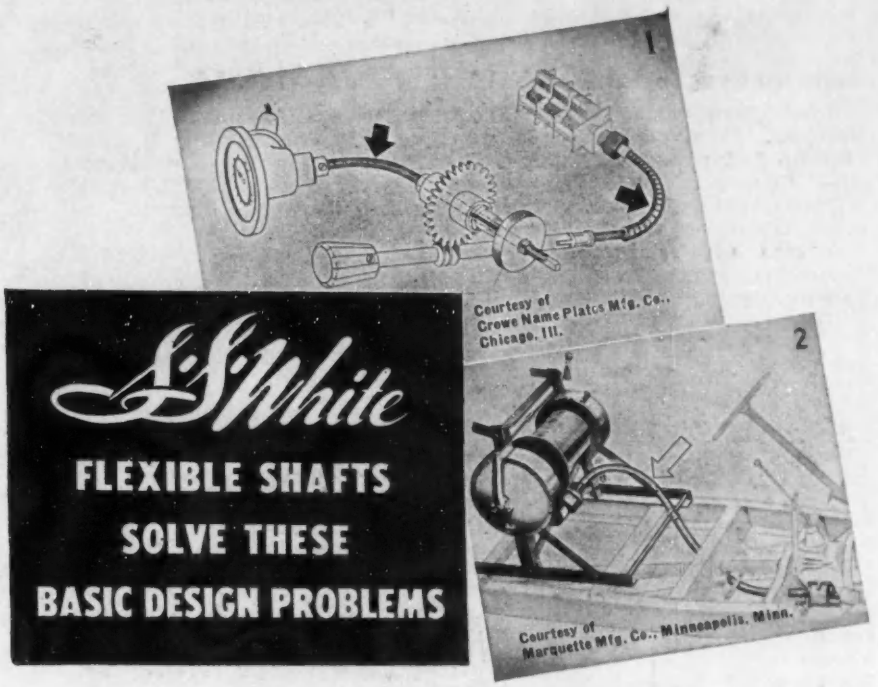
Engineers Club, Philadelphia; dinner 6:30 p.m. Meeting 7:45 p.m. Application of Atomic Power—Philip N. Ross, Westinghouse Electric Corp.

St. Louis—March 8

Garavelli's, Adolphus Room; dinner 6:30 p.m. Meeting 8:00 p.m. Planning and Operating an Airline Engineering Department—Charles Froesch, Eastern Airlines.

Southern California—Feb. 10

Rodger Young Auditorium, 936 W. Washington Blvd., Los Angeles, Calif.; dinner 6:00 p.m. Meeting 8:00 p.m. Must Air Transport Lose Money—Harold Koontz, director of commercial sales, Consolidated Vultee Aircraft Co.



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Southern New England—Feb. 10

Hotel Bond, Modernistic Room, Hartford, Conn.—dinner 6:45 p.m. Meeting 8:00 p.m. Gas Turbine Engine Combustion Chambers—Glenn Williams, associate director, fuels research laboratory, M.I.T. Talk will be illustrated with slides and movies. Technical Chairman: Prof. L. C. Lichty, Yale University.

Syracuse—Feb. 14

Syracuse Museum of Fine Arts; Dinner 6:30 p.m. Meeting 7:30 p.m. The Highway Traveler—Greyhound's New Intercity Bus—Milo M. Dean, chief engineer, Greyhound Corp.

Virginia—Feb. 14

Hotel Jefferson; dinner 6:30 p.m.

Washington—Feb. 8

Hotel Broadmoor, 3601 Conn. Ave., N.W., Washington, D. C.; dinner 7:00 p.m. Meeting 8:00 p.m. Ladies Night. Meeting to be held in honor of Dr. H. C. Dickinson, SAE past president, former head of the National Bureau of Standards, former chairman of Washington Section. Technical Chairman: W. K. Knauff.

Wichita—Feb. 17

Droll's Grill; dinner 6:30 p.m. Air-cooled Engines in Military Vehicles—Carl S. Bachle, vice-president in charge of research, Continental Aviation and Engineering Corp.

Williamsport Group—Feb. 7

The Anglers Club, Williamsport, Pa.; dinner 6:45 p.m. Joint meeting with Central Pennsylvania Section of the A.S.M.E. Engine Design With Regard to Service Life as Affected By Power Increases, Higher Compression Ratios and Supercharging—Max Roensch, Ethyl Corp.

Topic to be announced. Speaker: U. S. Rubber Representative.



New Members Qualified

These applicants qualified for admission to the Society between Dec. 10, 1948 and Jan. 10, 1949. Grades of membership are: (M) Member; (A) Associate; (J) Junior; (Aff.) Affiliate; (SM) Service Member; (FM) Foreign Member.

Baltimore Section

Laurance Stanford Haynes, Jr., (A), Robertson W. Wilhelm (A).

Canadian Section

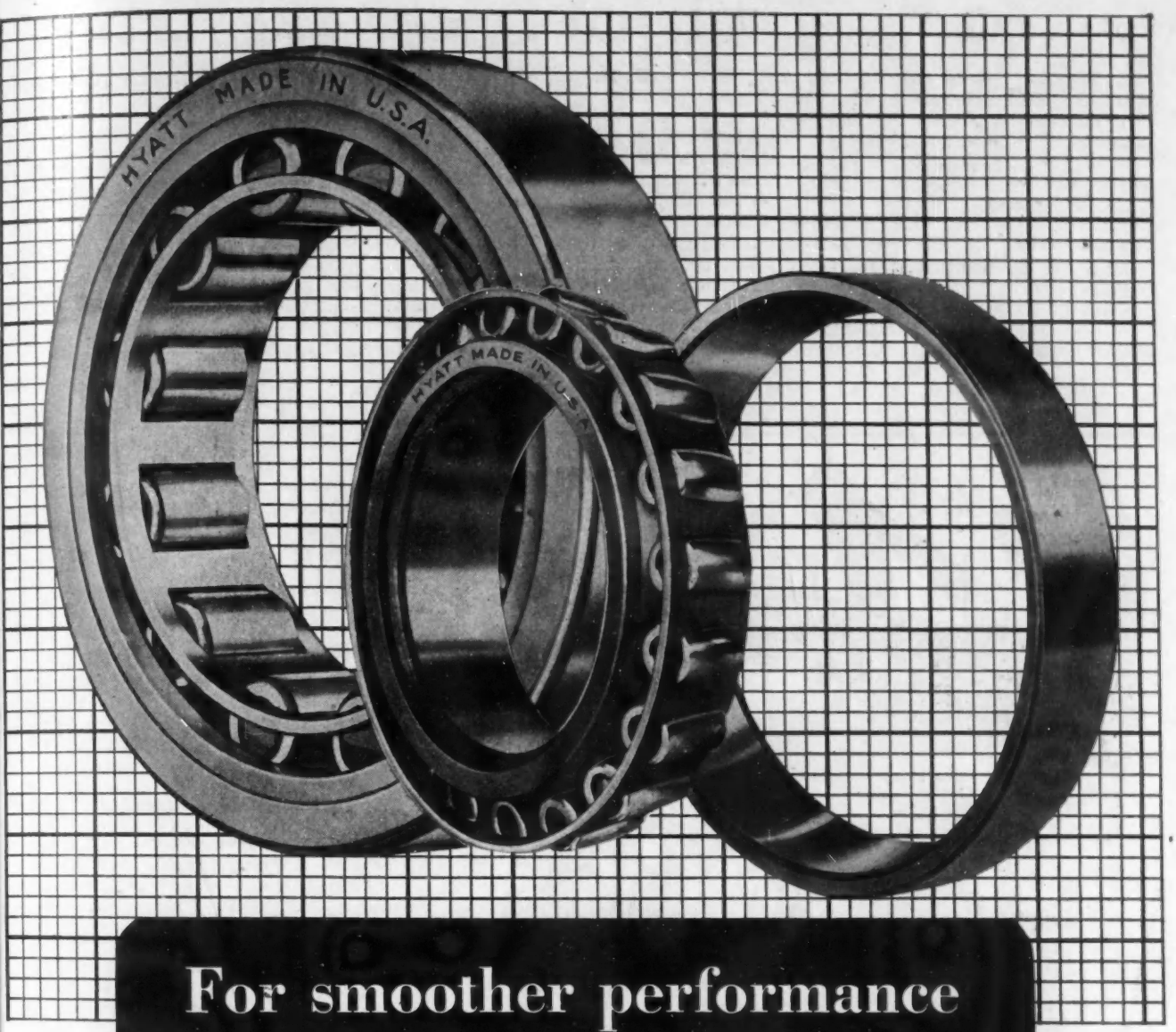
Harold S. Aspinall (A), Harold William McFadden (A).

Central Illinois Section

Thomas Edward Hrodey (J).

Chicago Section

Govind M. Asrani (J), Kenneth H. Barnes (M), Walter Miller Buben (A), Stephen T. Goode (A), C. Paul Kolthoff, Jr. (J), George W. Pontius, III



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Cincinnati Section

Geo. J. Hust (A).

Cleveland Section

John W. Cochrun (A), Leslie W. Hoberecht (J), John J. Novak (A), Frederic D. Wyss (A).

Colorado Group

Francis E. Raglin (J), Norman B. Spitzer (J).

Detroit Section

Charles Eugene Bierwirth (J), Norman L. Carpenter (M), Joseph Arthur Egan (J), Charles Lewis Freel (A), Roger T. Gaskill (M), Charles R. Goodyear (J), Herbert Russell Keesy (J), Semon E. Knudsen (M), Earl L. Morrison (M), H. A. Oestreich (A), Fay A. Roepcke (J), Lawrence I. Ruby (A), Richard Neil Shields (J), Robert R. Svenson (J), Miczyslaw John Waclawek (J), Oscar J. Wesa (J), Laurence Harold White (J).

Hawaii Section

Franklin Carl Leensvaart (A), Henry Hall Padgett (A), Francis S. Pugh (A).

Indiana Section

Robert D. Ball (J), William Mack Groover (J), Charles E. Kincaid (J), Phil C. Rust, Jr. (J), Stanley Clayton Tarrant (J).

Metropolitan Section

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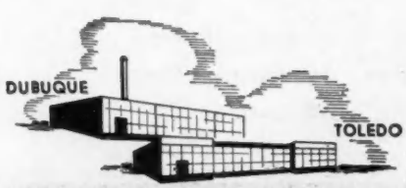
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Washington Section

Continued on p. 105



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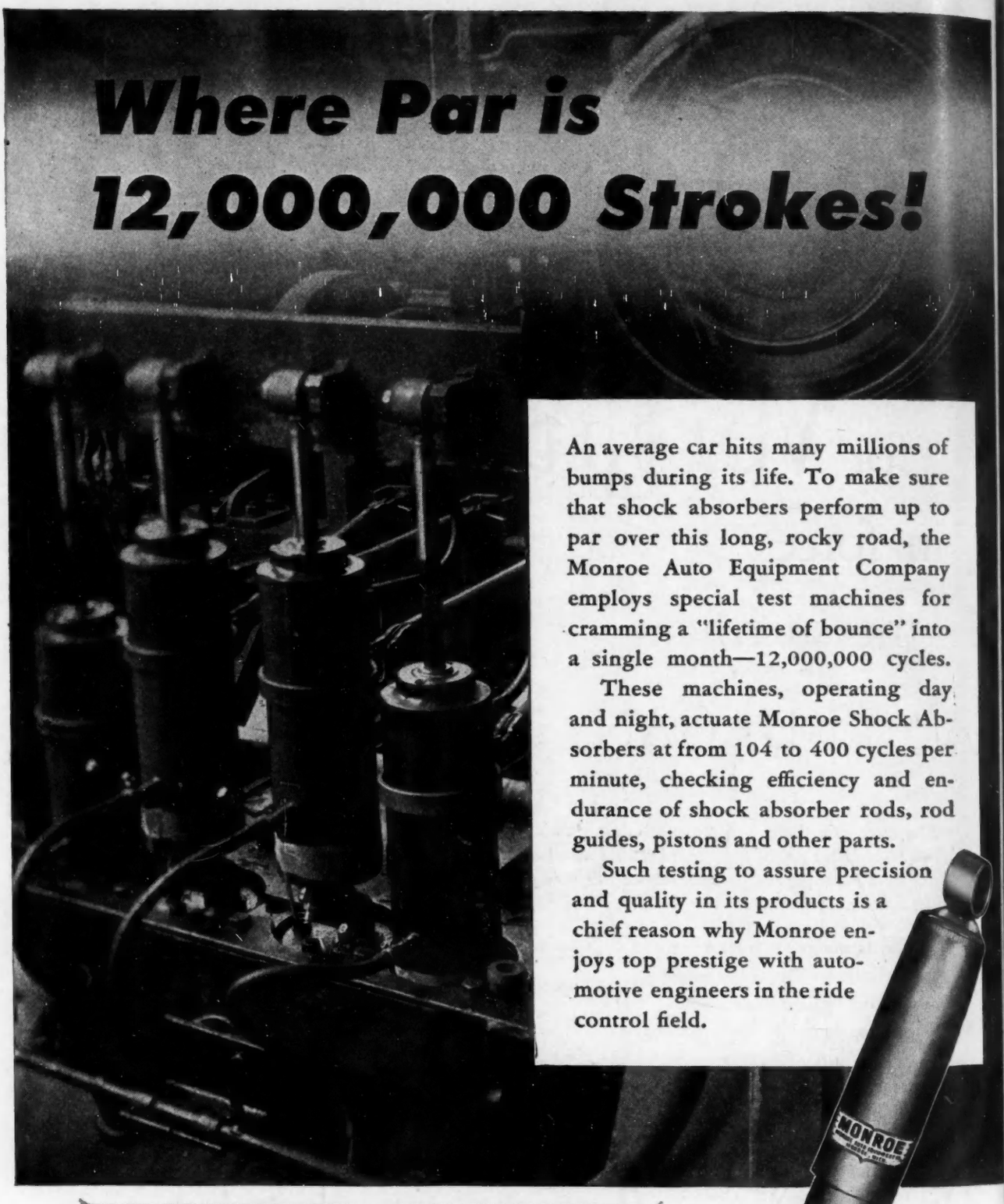
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Applications Received

The applications for membership received between Dec. 10, 1948, and Jan. 10, 1949 are listed below.

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Richard L. Ashley, James R. Byerts, George LeRoy Coleman, Grover C. Hartman, Jr., George R. Helwege, John Brooks Hilderbrandt, William F. Spatz, David H. Specht.

British Columbia Group

Albert Henry Bennett, John Duncan MacGregor, Roy S. Minter, George Vincent Meagher, Perry Moore, Reginald George Phillips.

Buffalo Section

James S. Thompson, Jr.

Canadian Section

William H. Bartlett, Robert Thomas Hazell, David Keith Jackson, Ivan S. Kaye, A. C. Pilger, Roy H. Sjoberg, John Watkin.

Central Illinois Section

John H. Babbitt, Jr., Edgar S. Cheaney, Max M. Gilbert, William Bernard Roth.

Chicago Section

Earle F. Clegg, L. A. Douglass, Brian M. Gallagher, Robert Arthur Klee, Robert L. Knight, George Matthews, Clarence Hugo Patrie, C. Robert Powers, William A. Radke, Clarence J. Russnak.

Cleveland Section

D. S. Kimball, Jr., Rudolph J. Schonitzer.

Dayton Section

Rudolph E. Olila, William Cedric Potter, Daniel Walther.

Detroit Section

Arthur W. Bingham, Russell A. Blanchard, Henry LeRoy Byerlay, John Williams Conley, Harvey Thomas Dickinson, F. Howard Grady, Emil B. G. Lefevre, Howard Vincent Lindbergh, Fred G. Loon, Charles Donald Moore, Robert Ullman, C. E. Patterson, John B. Ready, Frank Harwood Riddle, John A. Riopelle, Carl E. Scheiber, Harold G. Stringer, Edward H. Wallace, Clifford R. Warg, Stephen Woods.

Hawaii Section

Meyer Moldeven.

Indiana Section

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Metropolitan Section

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Northwest Section
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Oregon Section
E. T. Painter.

Philadelphia Section
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Pittsburgh Section
Harry R. Breniser, J. Preston Flaherty, James Edward McLean.

St. Louis Section
Earl E. Gould.

Salt Lake Group
Edward S. Brigman, Eugene C. Rollins.

Southern California Section
Allen S. Baker, Richard Edward Fisher, Frank W. Hodgdon, III.

Southern New England Section
Hayden D. Alexander, J. R. Glynn, Oscar G. Knapp, Lewis C. Stone.

Spokane-Intermountain Section
George W. Shields, Jr.

Syracuse Section
Latham Thomas Winfree.

Texas Section
F. E. Schmitz.

Twin City Section
Daniel J. Greenwald, Jr.

Washington Section
John D. Buchanan.

Western Michigan Section
Maurice W. Bolster, Charles R. Heimbuch, Edward J. Lavallee.

Outside of Section Territory
Gardner J. Fabian.

Foreign
Leslie Gordon Batt, England; Harold Sandford Clutterbuck, England; Joseph Ehrlich, England; Cyril William Mace, New Zealand; James Bellamy Mackaness, Australia.

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So that your SAE mail will reach you with the least possible delay please keep SAE Headquarters and the Secretary of your local Section or Group advised of any changes in your address. Such notices should be sent to:

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2. The Secretary or Assistant Secretary of your Section or Group at the addresses listed below:

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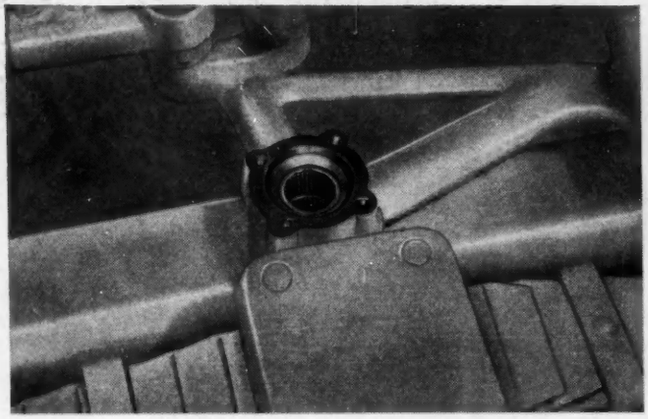
Torrington Needle Bearings

Keep Upkeep Down

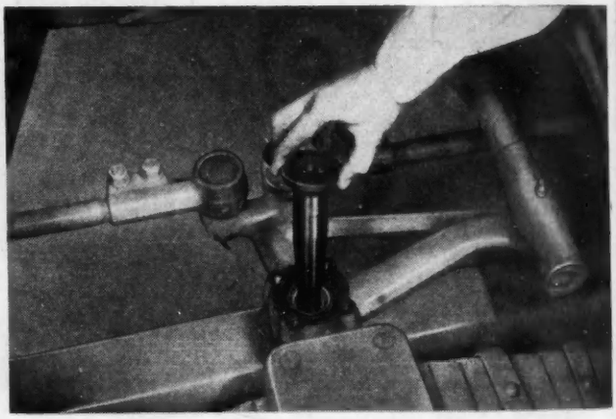
in "Caterpillar" Diesel Tractors



Heavy farm chores and tough construction jobs are a matter of course for "Caterpillar" Diesel DW10 Tractors. One feature owners like is a rugged design needing little upkeep. In governor, brake pivot shaft, steering gear and steering bellcrank, long service life is secured with efficient Torrington Needle Bearings.

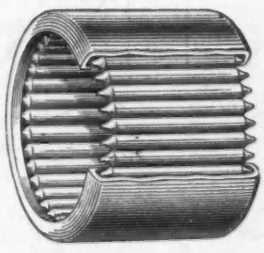


The bellcrank application in steering control shows how these high-capacity, anti-friction units fit into compact designs. Two Needle Bearings mounted with close fits keep mating parts in alignment. Freedom from wear maintains close bearing clearances and eliminates the need for readjustment.



Related parts of the assembly are simple—a plain machined bore for a housing, a hardened and ground shaft for an inner race. Fabrication is easy, and installation a quick arbor press operation. No retaining devices are needed. Such Needle Bearing features help keep manufacturing costs down.

Machinery you build or operate can be improved in operation and service life with Torrington Needle Bearings. Consult our engineers on your specific application requirements. THE TORRINGTON COMPANY, Torrington, Conn. or South Bend 21, Ind. District offices and distributors in principal cities.



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MACHINES MADE LIGHTER, MIGHTIER, WITH REYNOLDS ALUMINUM

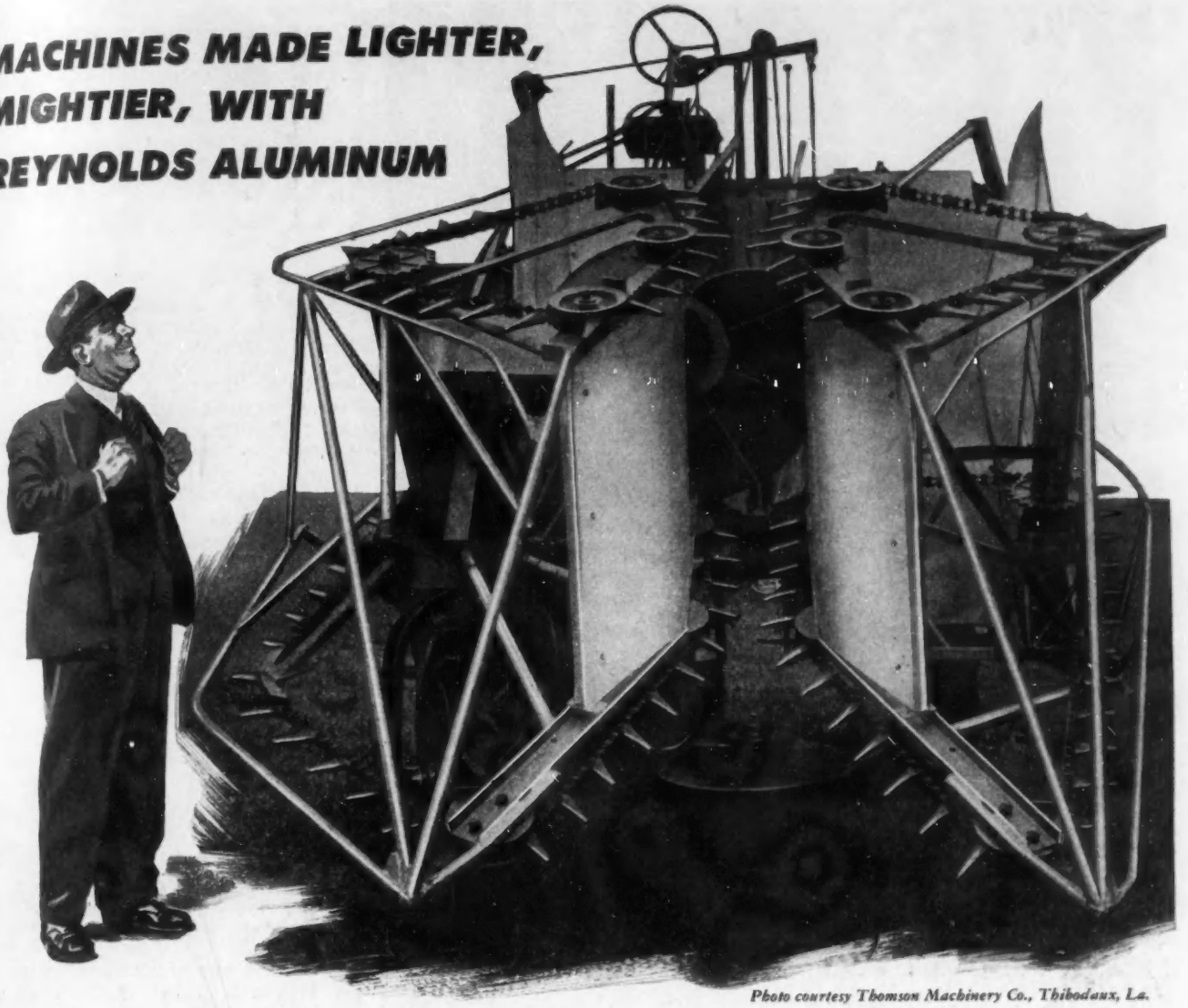


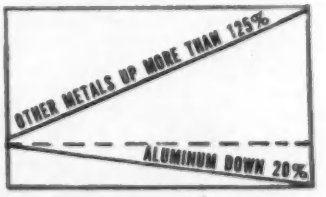
Photo courtesy Thomson Machinery Co., Thibodaux, La.

MUCH of the cost of raising sugar cane is in the cutting. The cane harvester in the picture above used to be overweight, had trouble getting over wet ground until aluminum replaced many heavy parts.

The manufacturer redesigned with aluminum—used aluminum bar and structurals in the frame work, replaced cast iron gear cases with strong, heat-treated aluminum castings. In fact, nearly 30% reduction of dead weight was made without sacrifice of strength. This allowed more engine—30 hp was added—never attainable with heavier metals. Now more cane is cut faster and harvest costs are lower, because lighter aluminum enabled the making of a mightier machine.

Here's proof of the part aluminum can play in improving your product. There are many kinds of aluminum that do many different jobs, better. Aluminum lets you forget rust, gives you a metal that's easier and faster to handle; it's strong even though ⅓ the weight of other metal. You can save on finishing cost—aluminum's bright natural finish stays bright. Shipping costs are less and sales appeal is tops. You can have all these benefits in extrusions, structurals, sheet, screw machine stock, wire, rod, bar and special shapes—in a wide range of alloys and tempers.

To get the lift of aluminum for your product, get the help of Reynolds experenced technicians. Call the nearest Reynolds Office, listed under "Aluminum" in the classified section of your telephone directory, or write to Reynolds Metals Company, Aluminum Division, 2514 South Third Street, Louisville 1, Kentucky.

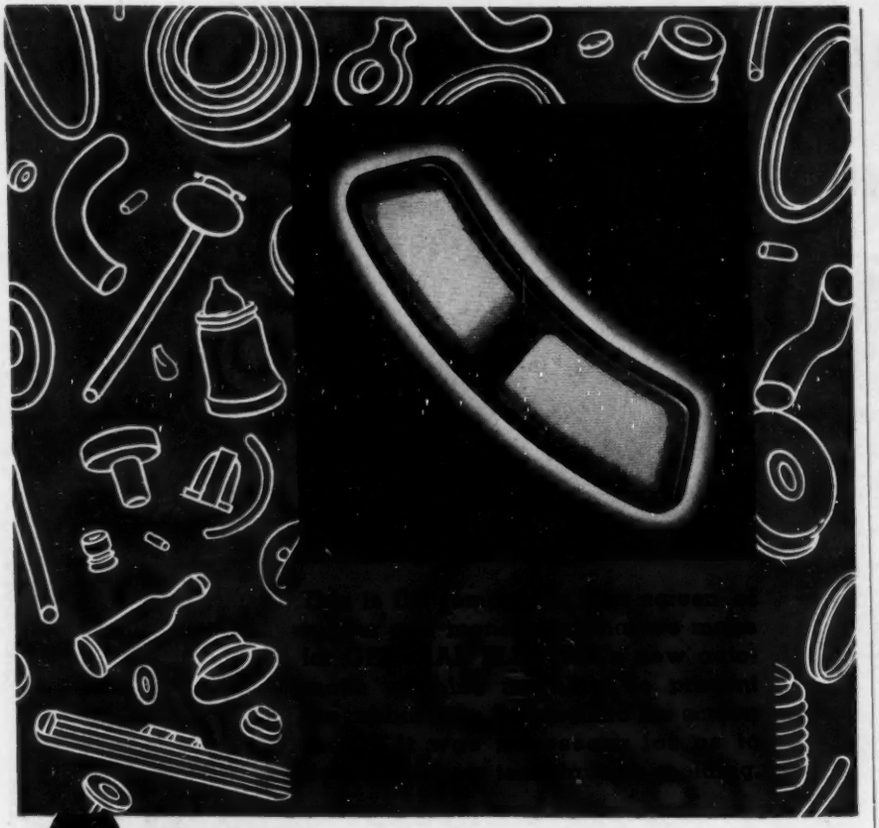


As a result of Reynolds becoming a primary producer, the base price of aluminum is now 20% below prewar levels.

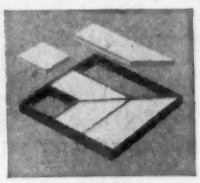


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REYNOLDS PIONEERING MADE ALUMINUM COMPETITIVE . . . TAKE ADVANTAGE OF IT!

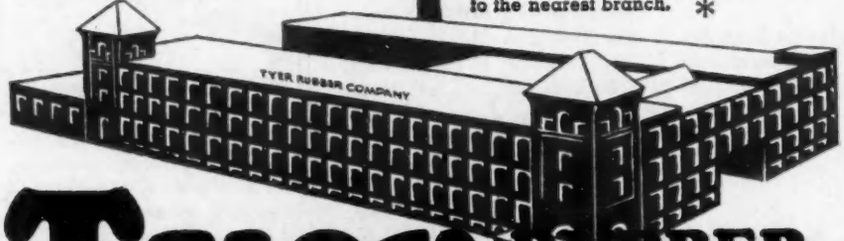


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If there is a rubber part in your product (old, new, or proposed) Tyer technicians will give you the utmost cooperation in putting all our experience at your service. Ask the Tyer representative. Write to us in Andover or to the nearest branch. *



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